This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

HARVARD UNIVERSITY.

LIBRARY

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY.

26,737

Exchange

September 30 1907 - April 27, 1908.

TRANSFERRED TO GEOLOGICAL SCIENCES LIBRARY.

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

TRANSACTIONS

OF

THE GEOLOGICAL SOCIETY

OF

SOUTH AFRICA.

VOL. X.

CONTAINING THE PAPERS READ DURING 1907.

EDITED BY THE HON. SECRETARY.

The Transactions can be obtained from the ASSISTANT SECRETARY,
18, National Bank Buildings, Simmonds Street, Johannesburg
(P.O. Box 1071);

Or from Messrs. WM. WESLEY & SON, 28, Essex Street, Strand
London, W.C.

JOHANNESBURG:
Printed at The Transvaal Leader Office, Harrison Street

1908.

Digitized by Google

LIST OF OFFICERS

OF THE

GEOLOGICAL SOCIETY OF SOUTH AFRICA

For the Year 1907.

President:

E. JORISSEN.

Vice-Presidents:

GEO. S. CORSTORPHINE. J. McCLELLAND HENDERSON.
H. KYNASTON.

Honorary Secretary and Treasurer:

J. H. RONALDSON.

Council:

WM. ANDERSON.
C. B. BRODIGAN.
J. T. CARRICK.
GEO. S. CORSTORPHINE.
†A. VON DESSAUER.
H. S. HARGER.
J. McC. HENDERSON.
W. G. HOLFORD.
G. G. HOLMES.
C. BARING HORWOOD.
W. A. HUMPHREY.
†H. LUTTMAN-JOHNSON.
†J. P. JOHNSON.
E. JORISSEN.
†C. B. KINGSTON.
H. KYNASTON.
*J. G. LAWN.
E. T. MELLOR.
E. H. V. MELVILL.
†F. P. MENNELL.
†A. W. ROGERS.
J. H. RONALDSON.
A. R. SAWYER.
F. W. VOIT.
*D. WILKINSON.
R. B. YOUNG.

*Resigned during the year. †Elected during the year

Assistant Secretary:

W. W. R. JAGO,

Office: 18, National Bank Buildings, Simmonds Street, Johannesburg.
Postal Address: P.O. Box 1071, Johannesburg.

Digitized by Google

CONTENTS.

Page

Petrographical Note on the Kimberley Slates in the Eastern Rand, –
By J. McClelland Henderson - - - 1

Petrological Notes on Rocks in the Vicinity of Craighall,
By P. A. Wagner - - - - - 6

Note on the Cobalt Lodes of the Transvaal,
By Professor R. Beck, Freiberg - - 10
(Translated and communicated by A. von Dessauer.)

Note on the Gold-bearing Rock of the Ayrshire Mine, Lomagundi, Rhodesia,
By Professor R. Beck, Freiberg - - 13
(Translated and communicated by A. von Dessauer.)

Notes on the Auriferous Conglomerates of the Witwatersrand,
By R. B. Young - - - - - 17

Note on the Correlation of the Bushveld Sandstone Series and the overlying Volcanic Rocks,
By H. Kynaston - - - - - 31

Note on the Field Relations of the Transvaal Cobalt Lodes,
By E. T. Mellor - - - - - 36

The Geological Structure of the Middelburg District, with special reference to the Character, Relationships and Thickness of the Waterberg System,
By E. T. Mellor - - - - - 44

The Marginal Phenomena and Geological Relations of the Granite North of Johannesburg,
By H. Kynaston - - - - - 51

The Alteration of the Felspars in the Felspathic Quartzite underlying the Hospital Hill Slates,
By R. B. Young - - - - - 62

Digitized by Google

Page

The Occurrence in Kimberlite of Garnet-pyroxene Nodules carrying Diamonds,
By Geo. S. Corstorphine - - - 65

Kimberlite Dykes and Pipes,
By F. W. Voit - - - - - - - 69

The Origin of Diamonds,
By F. W. Voit - - - - - - - 75

On a Collection of Permo-Carboniferous Plants from the St. Lucia (Somkele) Coalfield, Zululand, and from the Newcastle Dictrict, Natal,
By A. C. Seward - - - - - - 81

Gneiss Formation in Africa,
By F. W. Voit - - - - - - - 90

On the Supposed Kimberlite Magma and Eclogite Concretions
By T. G. Bonney - - - - - - 95

Further Remarks on the Kimberlite Rock and the Origin of Diamonds,
By F. W. Voit - - - - - - - 101

The Origin of River Diamonds within the Area of the Vaal,
By Hans Marensky - - - - - - 107

Note on Lherzolite and Eclogite Boulders from the Roberts Victor Mine,
By J. P. Johnson - - - - - - 112

The Tin, Molybdeum and Lead Occurrences near Potgietersrust,
By J. P. Johnson - - - - - - 115

Vol. X., pp. 1-68 (January-June, 1907) - - Published July, 1907

,, pp. 69-119 (July-December, 1907) - Published February, 1908

Digitized by Google

LIST OF PLATES.

		To illustrate Paper by
I.	Micro - Sections of a Cobalt Ore from Balmoral, Transvaal, and Micro-Sections of Hornblende Gneiss from the Ayrshire Mine - - - -	R. BECK
II.	Micro - Photographs of Auriferous Conglomerates of the Witwatersrand -	R. B. YOUNG
III.	Micro - Photographs of Auriferous Conglomerates of the Witwatersrand -	R. B. YOUNG
IV.	Micro - Photographs of Auriferous Conglomerates of the Witwatersrand -	R. B. YOUNG
V.	Geological Sketch Map of the Middelburg District, Transvaal - - - -	E. T. MELLOR
VI.	Geological Map of the Southern Portion of the Pretoria-Johannesburg Granite -	H. KYNASTON
VII.	Micro-Photographs of Felspathic Quartzites -	R. B. YOUNG
VIII.	Permo-Carboniferous Plants from Zululand and Natal - - - - - - -	A. C. SEWARD
IX.	Permo-Carboniferous Plants from Zululand and Natal - - - - - - -	A. C. SEWARD
X.	Ideal Cross-Section, 'Nkandhla-Fort Yolland	F. W. VOIT

Digitized by Google

LIST OF OFFICERS

OF THE

GEOLOGICAL SOCIETY OF SOUTH AFRICA

For the Year 1907.

President:

E. JORISSEN.

Vice-Presidents:

GEO. S. CORSTORPHINE. J. McCLELLAND HENDERSON.
H. KYNASTON.

Honorary Secretary and Treasurer:

J. H. RONALDSON.

Council:

WM. ANDERSON.
C. B. BRODIGAN.
J. T. CARRICK.
GEO. S. CORSTORPHINE.
†A. VON DESSAUER.
H. S. HARGER.
J. McC. HENDERSON.
W. G. HOLFORD.
G. G. HOLMES.
C. BARING HORWOOD.
W. A. HUMPHREY.
†J. P. JOHNSON.
E. JORISSEN.
H. KYNASTON.
*J. G. LAWN.
E. T. MELLOR.
E. H. V. MELVILL.
J. H. RONALDSON.
A. R. SAWYER.
F. W. VOIT.
*D. WILKINSON.
R. B. YOUNG.

*Resigned during the year. †Elected during the year.

Assistant Secretary:

W. W. R. JAGO,

Office: 18, National Bank Buildings, Simmonds Street, Johannesburg.
Postal Address: P.O. Box 1071, Johannesburg.

Digitized by Google

SEP 20 1907

VOL. X. JANUARY to JUNE, 1907. PP 1-68

TRANSACTIONS
OF
THE GEOLOGICAL SOCIETY
OF
SOUTH AFRICA.

CONTENTS.

	Page
Petrographical Note on the Kimberley Slates in the Eastern Rand, By J. McClelland Henderson	1
Petrological Notes on Rocks in the Vicinity of Craighall, By P. A. Wagner	
Note on the Cobalt Lodes of the Transvaal, By Professor R. Beck, Freiberg (Translated and communicated by A. von Dessauer).	10
Note on the Gold-bearing Rock of the Ayrshire Mine, Lomagundi, Rhodesia, By Professor R. Beck, Freiberg (Translated and communicated by A. von Dessauer).	13
Notes on the Auriferous Conglomerates of the Witwatersrand, By R. B. Young	17
Note on the Correlation of the Bushveld Sandstone Series and the Overlying Volcanic Rocks, By H. Kynaston	31
Note on the Field Relations of the Transvaal Cobalt Lodes, By E. T. Mellor	36
The Geological Structure of the Middelburg District, with special reference to the Character, Relationships and Thickness of the Waterberg System, By E. T. Mellor	44
The Marginal Phenomena and Geological Relations of the Granite North of Johannesburg, By H. Kynaston	51
The Alteration of the Felspars in the Felspathic Quartzite underlying the Hospital Hill Slates, By R. B. Young	62
The Occurrence in Kimberlite of Garnet-pyroxene Nodules carrying Diamonds, By Geo. S. Corstorphine	65

PRICE - TWENTY-ONE SHILLINGS.

JOHANNESBURG:
PRINTED AT THE TRANSVAAL LEADER OFFICE, HARRISON STREET
1907.

Digitized by Google

Digitized by Google

TRANSACTIONS

OF

THE GEOLOGICAL SOCIETY

OF SOUTH AFRICA.

VOL. X., 1907.

Petrographical Note on the Kimberley Slates in the Eastern Rand (Read 25th February, 1907).

By J. McClelland Henderson.

It is now some time since attention was first drawn to the Witwatersrand Strata as they occur on the Far East Rand. The similarity which obtains between the different slate beds and the difficulty experienced, especially in deep boring, in determining their horizon as above or below the Main Reef Series, lends unusual interest to any additional data which can be obtained. From their position, the banded slates of the Kimberley Series and the Main Reef Footwall Slates, which are found at the top of the Lower Witwatersrand Beds, demand chief consideration in this connection.

I am having analyses made of a series of specimens of Kimberley Slates and Main Reef Footwall Slates from boreholes in the Far East Rand to assist me in following out a comparative study of the two slate occurrences on lines suggested by Dr. Hatch's "Notes on the Witwatersrand Gold Deposits and their Associated Rocks."[1] The results are not

[1] *Trans. S A. Assoc. Eng.*, 1903.

Digitized by Google

yet all to hand, but in the notes submitted I wish mainly to bring to your attention, as offering several special points of interest, the analysis, by Professor Reinisch, of Leipsic, of a section of Kimberley Basement Slates from Daggafontein Borehole No. 6 at 2,025 feet.

PHYSICAL CHARACTERISTICS.

(a) *Macroscopic.*—The rock is the usual chloritic clay slate, associated with the Kimberley Series, and characterised by pronounced banding, indicating the old bedding planes. The slate is further traversed by fine lines of irregular course, consisting of quartz or chalcedony.

(b) *Microscopic.*—Microscopically, the bedding structure is best observed with a low power of magnification, say, 20 diameters, but not so well under high powers. The banding is due to the fact that the predominating quartz fragments are of larger dimensions in the light coloured portions, whence the quartz grains gradually decrease in size until they almost completely disappear and are substituted, more or less, by chlorite and sericite, when the next layer or band begins again with its large quartz particles. Owing to the purity of this quartz, which shows no enclosures whatever, these particles offer no special characteristics, which might form a guide in determining their origin from any particular rock.

The presence of mica is evidenced by muscovite, which is found in small scales parallel to the bedding planes. Sericitic mica is much more plentiful, in layers which exhibit a paucity of quartz.

Isolated, partly decomposed, scales of biotite occur, mainly in those light coloured layers, which are rich in quartz.

Chlorite, in small light green flakes, obtains throughout to a much greater extent than is commonly the case with clay slates, and to this may be attributed the higher yield of oxide of magnesium, as seen in the accompanying analysis, and the not inconsiderable loss on ignition. The chlorite is easily distinguished from the light green sericite by its inferior double refraction.

The rock also contains countless fine needles of rutile in clusters or groups, but occasionally also in large prisms or compact aggregates, which, however, clearly reveal the needle-like character in any protruding points, when observed under a high magnification of, let us say, 200 diameters. They frequently show a turbid yellowish crust of calcium titanate, leucoxene.

A carbonaceous substance, which glows at the burner, is also noted, but the quantity appeared too minute to identify the exact nature of the substance or determine the amount of carbon dioxide (CO_2) in the rock.

Occasional grains of ilmenite ($Fe\,Ti\,O_3$) may be observed, partly coated with leucoxene, as in the case of the aggregates of rutile, but distinguished from the latter by the absence of the golden yellow points.

Digitized by Google

Pyrite, recognisable by its colour, is irregularly but not abundantly distributed through the slate; it is possible therefore that the sulphur present is also contributed by some other constituent in the rock.

Besides the above, the microscope also reveals very occasional fragments of zircon and apatite; and in three microscopic rock sections a single minute pillar of tourmaline was noted.

CHEMICAL ANALYSIS.

Turning now to the chemical analysis of the rock, the figures here submitted are, with the exception of titanic oxide ($Ti\,O_2$) and oxide of magnesium ($Mg\,O$), the mean of two determinations. The magnesia was determined three times, because, although the first two values obtained coincided well, they appeared to be too high for a clay slate of this nature, and might be accounted for by an abnormal enrichment of chlorite. The titanic oxide was determined colorimetrically, this method being simpler and more reliable than evaporation, especially when dealing with small quantities. The results of the determinations were 0·70 per cent., 0·71 per cent., and 0·71 per cent. of $Ti\,O_2$. To ensure accuracy, as in this analysis the determination of the titanium was of the greatest interest, the titanic oxide was determined in two separate laboratories.

In the determination of the loss on ignition, the powdered rock was dried and heated to 108 degrees; besides $H_2\,O$, small quantities of CO_2 and SO_2 were detected but not separated.

The analysis yielded :—

$Si\,O_2$	51·17
$Ti\,O_2$	0·71
$P_2\,O_5$	0·08
$Al_2\,O_3$	19·92
$Fe_2\,O_3$	4·95
$Fe\,O$	3·92
$Mn\,O$	0·21
$Mg\,O$	8·92
$Ca\,O$	1·25
$K_2\,O$	1·35
$Na_2\,O$	2·16
S	0·03
Loss on Ignition	5·85
Total	100·52

In the section of slate analysed no gold was detected.

It may be of interest in this connection to compare the above analysis with one obtained by Mr. Horwood from between 3,050 and 3,170 feet in the No. 1 Borehole on the adjoining farm Grootvlei, and quoted in his publication "The Witwatersrand and Associated Beds."

Digitized by Google

Mr. Horwood's analysis is as follows :—

$Si\,O_2$	...	58·45, 7·38 per cent. greater than in my analysis.
$Ti\,O_2$	...	Could not be detected.
$Al_2\,O_3$	...	16·87, as compared with 19·92 in the present instance.
$Fe_2\,O_3$	...	10·69.
$Fe\,O$	...	not determined; 1 as compared with $Fe_2\,O_3$ 4·95 and $Fe\,O$ 3·92.
$Ca\,O$	...	shows traces in Mr. Horwood's analysis, while that of Professor Reinisch gave 1·25 per cent.
$Mg\,O$	...	in Mr. Horwood's analysis is 2·50, while the Daggafontein slate gives a comparatively high percentage of Magnesia—8·92 per cent.
$K_2\,O$	...	0·99 as against 1·35.
$Na_2\,O$	...	1·40 as against 2·16.
$Fe\,S_2$	...	(iron sulphide), 0·658.

The loss on ignition in the Grootvlei Slate is 8·08 as against the Daggafontein figure of 5·85 per cent.

In the analysis now submitted, the main point to which I wish to draw attention is the fact that, for the first time, as far as I am aware, the presence of titanium or titanic oxide ($Ti\,O_2$) has been proved in the slate by chemical analysis. Although the microscope apparently revealed the presence of this mineral in such quantity, chemical investigation to date had failed, it appears, to prove the presence of any titanium whatever, with the result that I have heard doubts expressed as to whether the microscopic identification of rutile were correct.

Mr. Horwood concludes that "the rutile must be present in very minute quantity compared with the bulk of the rock, since both Kimberley and Main Reef Footwall Slates were tested for titanium by the usual methods employed in rock analyses, and in neither case could even a trace of this element be detected."[2]

It is certainly the case that, judging from the evidence of the microscopic slide, one is apt to overestimate the quantity of rutile present and to suppose that there is at least 2 or 3 per cent., whereas analysis shows the titanic oxide in the slate to amount to barely ¾ per cent.

In studying the rutile occurrence, these Kimberley Slates were tested first, because, speaking generally, they appear under the microscope to contain rutile crystals in much greater abundance than the Main Reef Footwall Slates. I had the opportunity afforded me by Dr. Corstorphine some time ago of comparing a number of microscopic slides in this connection, and we both came to the same conclusion as to the abundant crystals in the Kimberley Slates. It was partly this, and the comparison with my own of some slides lent me by Mr. Holford, that led me to dwell

[2] C. B. Horwood, "The Witwatersrand and Associated Beds," 1905.

Digitized by Google

upon that fact, in my paper on the Far East Rand, read in 1905. How the chemical analysis of Main Reef Footwall Slates will compare with the microscopic results recorded to date is a matter that is now being investigated.

As indicated by the title, the foregoing is merely submitted as a note, recording the result of part of an examination of certain Witwatersrand Beds, as it was thought that such might possibly prove a useful record for those members who are likewise interested or engaged in this line of study, and to whom any additional items of information might be acceptable.

SUMMARY.

Summarised, the main features of interest are:—

1. The chemical investigation has proved and corroborated the microscopical identification of rutile in the Kimberley Slates of the Witwatersrand.

2. That the results yielded by such chemical analysis show that the percentage of rutile or titanic oxide ($Ti\,O_2$) is much less than one would estimate, judging by microscopic evidence alone. Compare the percentage of 0·71 $Ti\,O_2$ recorded in the chemical analysis with the apparent abundance of rutile manifested in the microscopic rock section from the same specimen of the slate.

3. That, outside of the above, the high percentage of magnesia is the chief feature that calls for attention.

Beyond these points, the results of the present analysis, which was made in Europe, tally more or less with the earlier analysis of the Kimberley Slates carried out in Johannesburg.

Digitized by Google

Petrological Notes on Rocks in the Vicinity of Craighall (Read 25th February, 1907).

By P. A. Wagner.

The rocks which occur in this district may be classified into :—

(1) Granite and allied rocks (the rocks of Craighall Ridge).
(2) Basic intrusions.
(3) Acid intrusions.

I propose dealing with them in the order given.

(1) GRANITE AND ALLIED ROCKS.

Although this part of the country is covered with a considerable thickness of soil there are numerous exposures of these rocks in the Hyde Park, Sandhurst, and Craighall Townships, and also in the bed of the Yokeskey River. The exposures generally take the form of flat masses, seldom rising to any height above the surrounding country, and have all a characteristic brown colour due to weathering.

As there are numerous varieties of these rocks I shall deal with each of them separately.

The typical granite of this neighbourhood is grey and hypidiomorphic in structure.

In hand specimens quartz, felspar, and mica can be distinguished.

Under the microscope the rock is seen to consist chiefly of quartz, microcline, orthoclase, oligoclase, biotite, and sphene, with decomposition products such as kaolin, epidote, chlorite, and muscovite.

The microcline is by far the most prominent constituent, and is generally remarkably fresh, even when the other felspars present may be in an advanced stage of decomposition. It is usually evident that it has been the last constituent to crystallise out by the way in which it encloses the other minerals, although exceptions to this will be touched upon later.

The quartz, which is abundant, usually gives a wavy extinction.

Both the orthoclase and the oligoclase are usually somewhat decomposed; some of the orthoclase is crowded with biotite, chlorite and sphene,

Digitized by Google

and secondary muscovite, probably in the form of sericite. Both felspars show a remarkable epidote decomposition. That this epidote has been formed in the felspars by ferruginous solutions derived from the decomposition of the biotite can be very clearly seen in places. In one particular instance I found comparatively fresh biotite, which changed to a chlorite pseudomorph, this in turn to flakes of chlorite, followed immediately by epidote in characteristic granular aggregates.

The predominant ferromagnesian constituent of this granite is biotite, which, although perfectly fresh in some sections, has in others been completely replaced by chlorite pseudomorphs.

The chief inclusions in the biotite are zircon and opatite, the former sometimes attaining considerable size.

I found several places where the orthoclase and other felspars had minute tongues of quartz projecting through them, thus giving rise to a structure very much resembling micropegmatite.

Some of these granite exposures show evidence of considerable shearing, and along some of these shearing planes there is even a development of schist, although in no place did I find a parallel arrangement of minerals such as exists north of Sans Souci.

This ordinary granite is traversed by numerous veins of fine grey granite, of which there are several varieties.

The fine-grained granite is similar in mineral composition to the older variety.

In one particular section of fine-grained granite from Rattray's Quarry, near Craighall Lake, I found a parallel growth of biotite and muscovite, this being the only example of primary muscovite which I found.

This fine-grained granite contains basic segregations, from which the coarser type is remarkably free. I examined one of these and found it to consist chiefly of biotite and sphene.

Pegmatite Veins.—These run through coarse granite in every direction; in some cases they are actually horizontal.

Their texture varies from quite fine up to very coarse varieties, the felspar crystals being sometimes 4 inches long. These veins are always much fresher than the granite which they traverse.

The pegmatite does not contain any tourmaline.

Graphic Granite.—This is also plentifully developed and always remarkably fresh, even when taken from quite close to the surface.

The colour varies from white to pink. Under the microscope it is seen to consist entirely of quartz and microcline.

Veins of aplite are also fairly common. These traverse the pegmatite and appear to be the youngest of these granitic rocks. Microscopically the rock is seen to consist of microcline, quartz, oligoclase, and biotite in very small quantities.

THE ROCKS OF CRAIGHALL RIDGE.

This ridge forms the most prominent topographical feature of the neighbourhood.

Digitized by Google

Coming from Johannesburg it is first met with to the west of Hyde Park Estate, and then runs almost as far as the Craighall Hotel Avenue. The direction is N.20 deg. W. magnetic (approximately true N. and S.). Throughout the entire length of the ridge there runs a series of felspathic rocks, granitic in appearance, traversed in all directions by innumerable quartz veins, with a principal north and south trend. These rocks usually occupy a less prominent position than the quartz.

On each side of the ridge, and strictly parallel with it, there are bands of schistose rock which were undoubtedly originally granite.

Under the microscope the rock is seen to consist of large grains of microcline and of undoubtedly primary quartz, showing a wavy extinction.

The microcline is seen to be traversed by a series of irregular veinlets of secondary quartz and interstitial sericite. These veins sometimes appear to branch off from a central vein.

The extent to which this silica replacement has gone on can be seen to vary greatly even in the same slide.

First there is the microcline, only traversed by cracks showing an occasional quartz grain. Then the veins can be seen extending in every direction, the grains of quartz in their growth actually pushing the felspar apart, so that twinning lines are no longer continuous; and finally only a quartz mosaic and sericite remain, though lines of sericite mark the previous position of the microcline. The mosaic replacement is not strictly confined to the felspar, but can also be seen taking place along cracks in the large grains of primary quartz; and it is not difficult to see that by such a process we would finally get a rock consisting entirely of small quartz grains and quartz mosaic with sericite.

On examining some of the rocks which in hand specimens look like quartzite, these are seen to consist entirely of such fine-grained quartz with lines of sericite, indicating the previous position of felspar crystals.

Having made this examination it is not difficult to conceive the history of this ridge.

From the abundance of very large grains of quartz and microcline in this felspathic rock one may conclude that the ridge was formed in the first place by a great pegmatite vein. Afterwards this pegmatite vein was repeatedly fissured, solutions saturated with silica travelled along the fissures, and from these into the fine cracks of the pegmatite, slowly filling the fissures and silicifying the rock itself.

(2) THE BASIC INTRUSIONS.

Of the basic dykes there are several exposures in the Hyde Park and Sandhurst Estates. In some places the contact between these rocks and the granite is actually exposed.

Under the microscope they are seen to consist of plagioclase felspars, chiefly oligoclase and andesine, quartz, biotite, hornblende—which is occasionally twinned—and abundant epidote. The epidote occurs in granular aggregates, as an undoubted decomposition product of the hornblende and the felspar, and also in large irregular cracked grains not unlike olivine. I have already drawn attention to a similar occurrence in the granites, although it is in these not nearly so plentifully developed.

Digitized by Google

In addition to these, distinct dolerite dykes showing characteristic ophitic structure occur further north, in the bed of the Yokeskey River.

I also examined a dyke which is exposed at the summit of the southern ridge. It was seen to consist almost entirely of chlorite, ilmenite, haematite and magnetite, and there were typical veins of quartz running through it, this showing that the silicification of the ridge had gone on long after the intrusion of these dykes.

(3) THE ACID INTRUSIONS.

The rocks which I shall describe under this heading form a small dyke outcropping on Kothe's Farm, north of the Yokeskey River, and striking N. and W. (magnetic).

The surface of these rocks is covered with a greyish crust, showing distinct lamination.

The unweathered portion is a dark coloured massive and exceptionally hard rock showing occasional porphyritic crystals.

I examined several sections of this rock.

No. 1 consisted of a cryptocrystalline ground mass of quartz and felspar, showing spherulitic structure. In this ground mass there lie porphyritic crystals of orthoclase, with somewhat rounded edges; round some of these flow structure is well developed. This may possibly give rise to the laminated appearance of the rock.

Biotite in long flakes, sometimes altered into chlorite, is present.

There are also large aggregates consisting of a mosaic of secondary quartz, with calcite sometimes twinned and epidote.

This rock is evidently a spherulitic rhyolite.

No. 2 consisted of a holocrystalline ground mass of lath-shaped crystals of quartz and felspar. The felspars are somewhat cloudy. There is also a quantity of secondary quartz.

In this ground mass are scattered phenocrysts of felspar. Abundant calcite and a little epidote occur in this rock. This rock must also be classed as a rhyolite.

Digitized by Google

Note on the Cobalt Lodes of the Transvaal
(Read 18th March, 1907).

By Professor R. Beck, Freiberg.

(Translated and communicated by A. von Dessauer.)

[Plate I., Figs. 1 and 2.]

In the *Zeitschrift für praktische Geologie*, 1889, pp. 271-274, Mr. R. Oehmichen, M.E., who was then my assistant, published a description of the Cobalt Lode on Kruis River, based on material for which we were indebted to the late Mr. D. Dörffel. The country rock in immediate contact with the lode was described as resembling aplite. According to the information received from Mr. Dörffel, the hanging, as well as the footwall, of the lode, was traversed by diabase dykes.

On a subsequent visit to Freiberg, Mr. Dörffel expressed a doubt of the correctness of his former determination as a result of more recent information collected in the field,—a doubt which he had also published in some South African journal. In consequence, I once more subjected the rock to a close investigation. A mistake in the specimens is excluded, as we have pieces of considerable size which show the aplite in contact with the cobalt ore, and others consist of aplite quite impregnated with cobalt-glance. From my slides, the rock is certainly not quartzite, but a quartz-feldspar rock with the feldspars largely altered to sericitic mica, as is so frequently the case in the vicinity of ore bodies. The feldspars in part still show the twinning of plagioclase. Some largish flakes of mica, also decomposed, but of primary origin, are interspersed. The structure of this rock likewise is not against its being an aplite. The quartz and feldspars have crystallised simultaneously, and both therefore show the very limited idiomorphism which we are accustomed to observe in such rocks.

Our aplite is probably the same rock which E. J. Dunn[1] described

[1] E. J. Dunn, "Further Notes on the Diamond Fields of South Africa," *Quart. Journ. Geol. Soc.*, London, vol. xxxiii., 1877, p. 883.

Digitized by Google

as early as 1877 to be the country rock of cobalt ores on the Kruis River, and which he then named "very fine-grained felsite."

Though somewhat late, I may also take this opportunity to correct a slight mistake which occurred in Mr. Oehmichen's paper. The very interesting amphibolitic cobalt ores referred to on page 273 do not come from Rooiwal, but from Balmoral, on the Pretoria-Middelburg line.

Since then Mr. D. Dörffel[2] described the peculiar and quite unique ore deposit of Balmoral. This induced me to re-examine the specimens from Balmoral (Eenzamheid), which he presented to me, and I beg now to submit some microscopical detail.

According to Dörffel, the lodes occur in a grey quartzite belonging to the Magaliesberg formation, which is overlaid by Waterberg shales, into which, however, the lodes do not pass. The permo-carboniferous Dwyka conglomerate close by contains boulders of these cobalt ores, which are therefore of pre-permian age. Mr. Dörffel records a boss of gabbro near to the outcrop of the lode and one of red granite a little further away.

Our specimens of the lode show first of all a distinctly crystalline central zone, consisting of highly decomposed plagioclase, greenish prismatic hornblende and cobalt-glance, and also, but in lesser quantities, titanite, epidote and quartz, and lastly, small quantities of molybdenite, which also occurs on the minute fissures of the country rock. The reproductions of the two sections (Plate I., fig. 1 and 2) illustrate the above statements.

The specimens show on both sides a very dense exterior zone, which is too highly altered to permit of an absolutely exact determination. It resembles most of all a hornfels, such as is found on the contact of diabase with shales. This dense zone is impregnated with numerous grains and crystals of cobalt-glance.

I take it that these lodes, owing to the green amphibole and titanite in them, are scarcely lodes in the strict sense, but mineralised dykes—in fact, they are mineralised and highly metamorphosed diabase dykes. I should like to suggest to my fellow geologists in the Transvaal to follow up this very interesting question.

It is possible that the dykes are connected genetically with the adjacent gabbro.

Mr. C. B. Horwood, in a paper on the Balmoral deposits, also takes the lodes to be dykes, but differs in describing them as pegmatite veins. The green prismatic hornblende, however, offers difficulties to his supposition. We are at one, however, in the view that the dykes were subsequently mineralised as the result of pneumatolytic and hydrothermal processes.

We know that elsewhere, in Norway, Canada, and other places, gabbro rocks which likewise have been metamorphosed with the separation of green hornblende, carry with their nickel contents a certain small amount of cobalt also. I have repeatedly shown that the mineralisation of such gabbros frequently went on even after the pyroxenes had

[2] D. Dörffel, "The Balmoral Cobalt Lodes," *Trans. Geol. Soc. S.A.*, vol. vi., part 5, pp. 93-94.

Digitized by Google

been altered. Our pyrrhotite deposits enclose green amphibolite. I described similar mineralised zones from Lohland, on the Spree, in a partially altered and amphibolitised proterobase, *i.e.*, a diabase which, in addition to secondary, contains primary amphibole also.

May it not be that the Transvaal cobalt lodes show similar conditions?

My slides from Balmoral prove at any rate that the introduction of the cobalt-glance continued after the formation of the green amphibole, because frequently the glance encloses fragments of this silicate. The formation of amphibole and the subsequent mineralisation are perhaps to be referred to post-volcanic action, which followed the eruption of the diabase. There is, however, also the possibility that the diabase rocks are pre-granitic, and that the said red granite caused the alteration to amphibolitic rocks, in accordance with an observation frequently made elsewhere that diabase has been changed to amphibolitic rocks inside the contact zones of granites, viz., in the region of Weesenstein and Berggiesshuebel, in Saxony. Should this last supposition prove correct, then the granite would have to be regarded as the mineralising agent for the cobalt.

Field work alone can decide these questions. I only wish at this distance to stimulate renewed enquiry into this interesting problem.

Explanation of the Illustrations.

Plate I.

Fig. 1.—*Micro-section of a cobalt ore from Balmoral*, magnified 25 times.—Cobalt glance (s.) and quartz (q.), as last-formed constituents in an aggregate of green hornblende (h.).

Fig. 2.—*Micro-section of a cobalt ore from Balmoral*, under crossed nicols, magnified 25 times.—Highly decomposed plagioclase (p.), green hornblende (h.), cobalt glance (s.)—the cobalt ore has been coloured with Indian ink.

Digitized by Google

NOTE ON THE GOLD-BEARING ROCK OF THE AYRSHIRE MINE, LOMAGUNDI, RHODESIA (Read 18th March, 1907).

By Professor R. Beck, Freiberg.

(Translated and communicated by A. von Dessauer.)

[Plate I., Figs. 3 and 4.]

As my friend, Mr. Von Dessauer, informs me, some Johannesburg geologists are surprised at my determination of the rock of the Ayrshire Mine as hornblende gneiss, and not as diorite,[1] and have suggested that my samples may have been changed in transmission. In order to test the matter once again, I asked for new specimens, and have now received one of a series which was given to Dr. Corstorphine by Mr. Berrington, the manager of the mine.

Even at the first glance, and later by careful microscopic examination, I was satisfied that no mistake had occurred, the only difference being the considerably greater gold content in the specimens presented to me in 1901 by the late Mr. D. Dörffel. A large number of grains of gold appear in these under the microscope in reflected light, but it requires a diligent search to discover even a minute speck in the specimen lately received. The material given me by Mr. Dörffel belonged to a series of picked specimens, which he informed me contained about 7 ozs. of gold per ton.

The rock in both specimens is, except for slight variations in grain, identical. I therefore confirm my determination. I should like to accentuate the fact that between a biotite-quartz-diorite, as the Johannesburg geologists prefer to regard the rock, and a hornblende gneiss, as I feel inclined to determine it, only structural and genetic differences exist. The mineralogical and chemical composition may be identical. I do not belong to those geologists, such as Dr. E. Weinschenk, of

[1] Prof. R. Beck, "Some Remarks on S.A. Ore Deposits," *Zeitschrift für Prakt. Geol.*, 1906, pp. 205-209.

Digitized by Google

Munich, who endeavour to banish the word "gneiss" altogether out of our science. I hold, in opposition to the statement, "Gneiss no longer exists," that this good old name, dear to the miner, should be retained for such metamorphic eruptive and sedimentary rocks, which after their original solidification acquired a parallel structure.

The Lomagundi rock is, however, in my opinion, no longer an original product of solidification; it is no longer an unaltered quartz diorite of normal structure, containing biotite and some orthoclase, related, as its composition would appear to indicate, to the Alpine tonalites. Much rather does it show distinct indications of re-crystallisation which resulted in the production of those peculiarities of structure characteristic of gneisses and other crystalline schists.

It possesses first a distinct foliation which cannot be explained simply as fluidal structure inasmuch as it is produced by the parallel arrangement of secondary green hornblende. All the other structural conditions also are those of typical crystalline schists.

The chief constituent, a plagioclase, which proved to be oligoclase, and also the less frequent orthoclase, often contain enclosures of quartz grains and minute prisms of greenish or colourless hornblende, and also scales of biotite. The green hornblende is columnar; with enclosures of quartz, it contains ilmenite, sphene, pyrites and zircon. The borders of the hornblende crystals are often indented by the adjacent grains of feldspar and quartz. The normal sequence in the crystallisation of the constituents of such magmas, where quartz ought to be the last formed, has therefore been disturbed, as in all rocks of granoblastic structure. With this the tendency of the quartz and feldspars to form small polygonal grains is connected. The result is a kind of mosaic, which can be well seen under crossed nicols, especially on a cross-section (Plate I., fig. 3). Large tabular idiomorphic feldspars are on the other hand entirely absent. As in many gneisses, here too a portion of the potash feldspars has been altered into microcline, and some of the lime from the decomposition of the plagioclase has been applied to the formation of small, colourless garnets. From the same source is the epidote, which is scattered here and there in longish grains. Zoisite could not be determined with certainty in my samples. Ilmenite is sometimes found attached to sphene, which also occurs in numerous, independent particles. In addition to the minute grains and crystals of gold, there are also some pyrites and a light-coloured ore, striped on certain planes, which form irregular grains or else well-defined minute crystals. It was proved by panning to be arsenical pyrites, containing a small amount of cobalt, according to an analysis by my colleague, Prof. Kolbeck. Finally, graphite may occur, as was pointed out to me in some Ayrshire specimens which I saw at Bulawayo.

I had completed the above investigations when I received two important papers from Prof. J. W. Gregory, of Glasgow, dealing with his investigations in Rhodesia.[2] In his second paper he gives an exhaustive

[2] J. W. Gregory, F.R.S., "The Ancient Auriferous Conglomerates of Southern Rhodesia," paper read before the Inst. of Min. and Met., London, 17th May, 1906, pp. 563-578; "The Mining Fields of Southern Rhodesia in 1905," *Trans. Inst. Min. Eng.*, Glasgow, 14th February, 1906.

Digitized by Google

study of the Ayrshire Mine, which in the interval has also come to the knowledge of South African geologists. The gold occurs, according to him, on three diorite leaders (three main bands of diorite), which are interbedded with hornblende schists in the immediate vicinity of a large mass of coarse-grained grano-diorite. He distinguishes in the Ayrshire Mine three types of diorite, all of which are, in my opinion, no longer primary rocks, but metamorphic, although originally of dioritic nature. Of his third type he speaks as follows on page 38: "The third type is a hornblendic or dioritic gneiss with a conspicuous, but usually irregular foliation." This type is also represented in the specimens I obtained from Mr. Dörffel, and later from Mr. Von Dessauer. Dr. Gregory therefore fully concurs with my determination of the Ayrshire rock in question.

On one point, however, this author fails to give us exhaustive information, and that is on the origin of the gold in the hornblende gneiss. He says: "Some of the gold is in the quartz and some in the hornblende, but most of it occurs on the borders of the hornblende crystals, and the form of the gold specks suggests that it may be a replacement after ilmenite" (p. 41). Against this I repeat what I state on p. 489 of the second edition (1903) of my book on "Erzlagerstätten," that the gold grains are found in the Ayrshire ore as enclosures, not only right in the quartz and green hornblende, but also in quite fresh plagioclase and orthoclase, and also in epidote. *The gold, therefore, cannot have entered the rock after the alteration of the dioritic rock, but must have participated in the metamorphism.* As the feldspar and hornblende decomposed under atmospheric influences, the gold near the surface would to a large extent be liberated from its enveloping silicates, and, as is known in other goldfields, would be concentrated in the upper levels. This explains why the yield of gold is less in the lower levels of the Ayrshire Mine than near the outcrop.

We do not know whether the gold was separated from the primary magma or was an impregnation from without. The re-crystallisation of almost all constituents, and possibly also of the gold, has deleted all traces of the primary conditions. Both eventualities, however, are possible. In support of the former a great number of instances have been described, quite recently the very convincing occurrences in British Columbia.[3]

Very remarkable are the conclusions of Mr. J. W. Gregory that the gold is distributed unequally in the different types of rock. These are best given in his own words *in extenso*:—

"The more massive type of diorite is comparatively barren, yielding only from ½ to 1 dwt. of gold to the ton. This rock occurs mainly in the central section, as on both sides of the cross-cut from the Edwards Shaft. The eastern workings are mostly in the white, richly feldspathic re-crystallised dioritic gneiss. This part of the mine is not much faulted, and the rock contains little free gold. It shows up to 7 or 8 dwts. of gold, and local patches give, according to Mr. E. D. Berrington, as

[3] R. W. Brock, "Original Native Gold in Igneous Rocks," *The Eng. and Min. Journal*, 1904, p. 511.

Digitized by Google

much as 90 dwts. The richer ores of the mine are at the western end, where the grano-diorite is from 40 to 50 feet distant. The ground is broken through here by a series of transverse faults, which displace the rocks on the western side to the north. The western section of the mine contains the most basic part of the dyke, and is rich in hornblende and biotite. The rock is dark-blue in colour, and as a rule conspicuously banded; it is often very rich in free gold, assays sometimes yielding 40 or 50 ozs. to the ton. A sample of this rock, which Mr. E. D. Berrington kindly gave to the writer, shows gold freely under the microscope. The rock consists of cross-twinned, fractured grains of plagioclase, some secondary hornblende and quartz-mosaic. Bands of epidote occur, and may be derived from some primary hornblende."

It appears from this description that the gold contents are higher in those portions which have undergone the highest metamorphism—that is, exactly in those for which we have chosen the designation hornblende gneiss—than in the less altered zones which more resemble a true diorite. This seems to speak for a concentration during the metamorphism of the diorite.

We have therefore to distinguish the following succession of events in the Lomagundi rock:—

1st.—Solidification of a dioritic magma, either
- (a) With the contemporary crystallisation of very scattered particles of gold; or
- (b) With a subsequent impregnation with very scattered particles of gold.

2nd.—Metamorphism of the diorite into hornblende gneiss, with a concentration of the gold in the very highly altered zones.

3rd.—Surface concentration of the gold liberated on weathering of the country rock.

Explanation of the Illustrations.

Plate I.

Fig. 3.—*Micro-section of hornblende gneiss from the Ayrshire Mine*, under crossed nicols, and 30 times enlarged.—In the centre microcline (specimen obtained from Dr. Corstorphine).

Fig. 4.—*Micro-section of a hornblende gneiss from the Ayrshire Mine*, under crossed nicols, and 30 times enlarged.—Shows a slightly coarser grain (specimen from the late Mr. D. Dörffel).

Digitized by Google

Notes on the Auriferous Conglomerates of the Witwatersrand (Read 18th March, 1907).

By R. B. Young.

[Plates II., III., IV.]

The following notes on the "banket," which I hope to continue later, are based on a study of specimens taken from the mines at intervals along the "reef," from the West to the East Rand. I have examined about one hundred and fifty microscopic sections of the rock.

Allogenic Constituents.—Almost all of the allogenic or original constituents of the banket are noted or described in the papers of previous writers. The well-rounded pebbles of vein quartz and of quartzite, with the somewhat angular fragments of cherty and jaspideous rocks, sometimes distinctly banded, are what one would naturally expect from the disintegration and subsequent attrition of the rocks of the Archæan System. Generally, these pebbles possess so little individuality as to render it impossible ever to ascertain their precise place of origin. Occasionally a pebble of abnormal composition is met with. For instance, in a microscopic section (No. 51) of the Main Reef, from the Geldenhuis Main Reef Gold Mine, I found a pebble of a quartz-tourmaline rock. The quartz is in the form of a medium-grained mosaic. The tourmaline, which forms a considerable portion of the rock, is of the ordinary dark-coloured type, and in the section appears brown, with here and there a slight bluish tint, when viewed by transmitted light. It occurs in radiate bundles of minute needles, which penetrate the quartz grains (see Plate IV., fig. 9). The frequent presence of fragments of tourmaline in the matrix of the banket makes it probable that the rock contains many similar pebbles, though in some cases the mineral may be of secondary origin.

Iridosmine.—Among the rare minerals associated with the banket, and in all probability of allogenic origin, is iridosmine. This mineral,

Digitized by Google

as far as I am aware, has not hitherto been described from this rock. It is obtained from the crushed ore of the Du Preez Series at Rietfontein, but in quantities too small to be of commercial value. It is got in flattened and rounded grains, and in tabular six-sided rhombohedral crystals, both averaging in diameter about 0·12 mm. In the crystals the basal and rhombohedral faces are distinct, the prism faces less so or absent. The basal cleavage is distinct, many of the grains being in the form of basal flakes, probably produced, in part at least, during the crushing of the rock. The colour varies from tin-white to steel-grey, and the lustre from splendent to dull. The hardness lies between 6 and 7. A very impure sample of the mineral gave a specific gravity of 17·9. On testing for osmium, I obtained results which show that this element is present in considerable quantity. It seems not improbable that there are other minerals of the platinum-iron group mingled with the iridosmine.

Authigenic Minerals: *Silica.*—In the metamorphism of the banket the dominant process was silicification. The secondary quartz is often difficult to distinguish from the primary quartz, with which most frequently it is in optical continuity. Occasionally the outlines of the original grains are indicated by lines of dust-like inclusions, or of minute flakes of sericite. Lines of liquid and gaseous inclusions traversing the primary quartz, and formed prior to the secondary quartz, are a useful distinguishing feature. Often very slight differences have to be relied upon, and very frequently it is impossible to define the limits of the original quartz grains.

The secondary quartz also occurs as fine-grained mosaics, frequently enclosing scattered flakes of sericite, chlorite, or talc. Occasionally a finely columnar form of quartz is met with, generally bordering crystals of pyrite, and forming veinlets in the same mineral. A finely fibrous chalcedony is also found, and seems in most cases to have been formed subsequent to the cementation of the rock. In a specimen of banket from the Black Reef, shown me by Mr. G. G. Holmes, is an agate of irregular shape, and enclosing a small core of the matrix of the banket. I have also observed traces of agate structure in the marginal region of a large highly pyritic nodule from the Meyer and Charlton Gold Mine.

In specimens of banket from the Battery Reef Leader of the Lancaster West Gold Mine, there occurs a fibrous form of secondary silica, which may have to be referred to chalcedony, but which differs in microscopic appearance from those examples of chalcedony with which I am familiar. It forms most often concavo-convex growths at the acute terminations of certain flat ellipsoidal nodules of pyrite, which are a feature of some portions of this rock. These growths might be likened to the root-caps at the terminations of vegetable roots. The fibres are generally somewhat bent, and between the individual fibres there frequently lie in parallel position flakes of sericite. The true form of the fibres is revealed on comparing longitudinal and transverse sections. The average transverse diameter of a single fibre varies in length from 0·01 mm. to 0·4 mm. The fibres have exceedingly irregular forms in transverse section, and are intimately interlocked. While some of the

Digitized by Google

fibres are isotropic in a roughly transverse section, many are not so, thus proving that the fibres are not strictly parallel. In length the fibres vary from very minute dimensions up to 2 or 3 mm. A longitudinal section gives an erroneous impression of the fineness of the fibres, owing to their intimate interlocking. The mineral is optically negative, and in this respect agrees with chalcedony. In referring to it later, I shall speak of it as "fibrous silica." It was formed in the rock very late in its history, as will be demonstrated further on when dealing with the pyritic nodules (see Plate II., figs. 1, 3; Plate III., fig. 6).

The replacement of coarse-grained primary quartz by a finer-grained secondary quartz, and sometimes chalcedony, can frequently be seen in microscopic sections of the banket. This is well illustrated in Plate IV., fig. 10. The replacement of chloritoid by quartz is described below.

Chloritoid.—Chloritoid is one of the most characteristic authigenic minerals of the banket, and also of the pyritic bands of the auriferous pyritic quartzite which frequently underlies the Main Reef. When it is absent its place is taken by chlorite and sericite, but in such cases the latter minerals may be taken to be in great part alteration products of the chloritoid, which mineral may frequently be seen undergoing this change. Some of the features of this mineral are described by Messrs. Hatch and Corstorphine.[1] It occurs in flat plates which are of a green colour and pleochroic. The colour and pleochroism vary in intensity, and sometimes in very thin sections are not easily discernible. It is frequently found in isolated crystals, but very commonly in clumps of crystals, generally rosette-like (see Plate III., fig. 8). The chloritoid is invariably idiomorphic to the pyrite, and where this does not seem to be the case the appearance is due to the fact that the pyrite has grown in contact with the chloritoid subsequent to the partial replacement of the latter mineral by quartz. There can be no doubt that chloritoid was one of the earliest secondary minerals to form in the banket. There is some evidence that in exceptional cases this mineral may have originated at a later stage.

A study of the alteration of the chloritoid is essential to an understanding of the rock, as we now find it. The most general change is a partial replacement by quartz, which may contain some scattered flakes of sericite or chlorite. As a result, the chloritoid crystals become ragged and lose more or less of their crystal outlines. It is not uncommon to find a crystal broken up into three or more ragged segments separated by quartz, but retaining undisturbed their original optical orientation, and showing traces of the crystal outlines still in line. I have also observed the position of the original crystal boundaries partially indicated in the secondary quartz by broken lines of very minute inclusions. In some cases the broken outlines of the chloritoid are doubtless due to the conditions of its growth. In many portions of the banket no further alteration besides replacement by quartz can be

[1] *Trans. Geol. Soc. S.A.*, 1904, vol. vii., pt. iii., p. 142.

Digitized by Google

noticed. Very frequently, however, another and generally later change has occurred, and the chloritoid, in most cases already partially replaced by quartz, has altered to chlorite or sericite, with which a small proportion of quartz may be mingled. The composition of chloritoid may be taken to be expressed by the formula H_2 (Mg Fe) Al_2 Si O_7, and therefore in the course of replacement of the mineral by quartz a small amount of water was probably liberated along with soluble iron and magnesian salts. If, as my observations go to prove, this action was general throughout the banket during an early stage of its metamorphism, it is possible that these solutions played some part in the reducing actions to which the mineralisation of the banket is due. Whether this was the case or not, no one who carefully studies the banket in microscopic sections can fail to observe the close relation that exists between the distribution of the chloritoid and the pyrite. Generally speaking, where chloritoid or its alteration products are abundant, there pyrite is abundant also, and *vice versa*.

Pyrite.—The study of the occurrence of pyrite in the banket is of especial interest, because of this mineral being generally the gold-bearer of the rock. There has been considerable discussion as to whether the pyrite is allogenic or authigenic in origin. That some of it in its present form is not detrital there cannot be the slightest doubt. In a number of the microscopic sections that I have examined almost every grain of pyrite present is beautifully crystallised, and shows not a trace of rounding. This is best exemplified in certain sections (Nos. 48-52) of a portion of the Main Reef from the Geldenhuis Main Reef Gold Mine. Nevertheless it is the fact that a large proportion of the pyrite in the banket occurs in the form of rounded grains. Becker[2] considers these to be of detrital origin, and speaks of them as pyrite pebbles. He states that their average diameter is 0·1 mm., and that they constitute most of the pyrite in the banket. Messrs. Hatch and Corstorphine,[3] in combating this view, have followed the example of Mr. Franklin White[4] in bringing forward grounds for believing that the comparatively large pellets of pyrite or marcasite, such as occur at Buffelsdoorn and Rietfontein, do not owe their form to attrition. But Becker did not refer to these bodies, which, according to Mr. White, he never had an opportunity of observing; so that this line of criticism must be looked upon as somewhat beside the mark. I have given careful attention to the true "pyrite pebbles" of Becker, and though it is impossible to prove that such as occur imbedded in secondary material are not of detrital origin, yet from the fact that they resemble exactly both in form and size pyrite grains that are obviously replacements of primary quartz, and of which examples are easily found, I am of opinion that the rounded form of a pyrite grain affords no reliable evidence of its detrital origin. However, more conclusive evidence is to be found in the relation of the pyrite to the chloritoid. The latter mineral, as

[2] Annual Report, U.S.A. Geol. Survey, 1896-7, pp. 166-167.
[3] *Op. cit.*, p. 141.
[4] *Trans. Geol. Soc. S.A.*, vol. iv., pt. iii., pp. 55-56.

Digitized by Google

I have already pointed out, is always idiomorphic to the pyrite, when the two minerals occur in contact. This could hardly be the case if any considerable proportion of the pyrite was present in the banket from the beginning, and the assumption by Becker[5] of a small amount of re-crystallisation of the pyrite does not get over the difficulty.

Becker[6] and others have remarked the common occurrence of pyrite as inclusions in the pebbles of the banket. It is obvious that the pyrite films that so often occur along the cleavage cracks of the pebbles are of late secondary origin, but I do not know of any satisfactory grounds for stating the same regarding the crystals of pyrite that occur in the heart of pebbles, even though they occur in connection with cracks. As far as I have observed, these crystals are much larger than those found in the matrix of the banket. In only one of my microscopic sections (No. 105) have I met with an occurrence of this kind. There are two crystals lying on the line of a crack. The average diameter of their sections is about 0·8 mm. The quartz that surrounds them shows signs of strain, there being a number of lines of liquid and gaseous inclusions radiating from the pyrite through the quartz, which between crossed nicols exhibits an undulatory extinction closely related to the lines of inclusions.

While examining microscopic sections of the banket, I was struck by the frequent occurrence of pyrite, which was obviously not only of authigenic or secondary origin, but which must have come into the rock subsequent to cementation. This later generation of pyrite is in the form of nodules, irregular patches and isolated crystals and grains.

The nodules can be very satisfactorily studied in portions of the Battery Reef Leader from the Lancaster West Gold Mine. In 1898 Mr. Franklin White[7] exhibited specimens of this rock at a meeting of this Society. He pointed out that in some cases the nodules rested in "cavities eaten into the solid faces of the pebbles themselves," and that occasionally they were traversed by "ribs of silica." The specimens of the rock that I have examined came from the 6th Level Drive, vertical depth 419 feet.

The nodules are of different kinds, but the most conspicuous type has a flat ellipsoidal form, the shortest diameter varying generally from 1 mm. to 3 mm., and the largest from 2 mm. to 1 cm. Others are roughly spherical. The external surface of most of the nodules is comparatively smooth, but in some cases it is roughened by crystals projecting from the nodules, as is generally the case with the "buckshot pyrite" of the Du Preez Series. The fracture has commonly a finely granular appearance with a dull lustre, but that of some of the nodules reveals a coarse texture and has a bright lustre. Many of the nodules, when examined with the naked eye, appear to be composed entirely of pyrite, while others evidently enclose particles of quartz and other minerals. They are frequently traversed by veinlets of secondary silica, the "fibrous silica" already described, the fibres being roughly

[5] *Op. cit.*, p. 167.
[6] *Ibid.*
[7] *Loc. cit.*

Digitized by Google

perpendicular to the walls of the veinlets, but generally slightly curved. The same mineral may frequently be observed partly bordering the nodules and other small pyritic bodies. The general direction of the veinlets is often the same in different nodules, and appears to coincide with directions of easy fracture in the large quartz pebbles. If this is general, then it is obvious that the fracturing must have occurred after the formation of the nodules, but before that of the veinlets of "fibrous silica."

A study of microscopic sections of the rock reveals beyond any doubt that the nodules of pyrite have been formed by replacement of the quartz, primary and secondary. I shall demonstrate this and some other features with the help of a few microphotographs.

Plate II., fig. 1 (diam. x 17) shows the appearance between crossed nicols of a portion of the margin of a nodule. The nodule consists of a central core of pyrite surrounded by an outer zone of pyrite and quartz. Its form in section is elliptical, the shorter diameter being about 7·5 mm., the longer about 9 mm. The two diameters of the core are about 3 mm. and 6 mm. In the centre of this core is a well-marked irregular line of cavities filled with chalcedony. The pyrite in contact with the chalcedony shows crystalline outlines. When viewed by reflected light, the pyrite of the nodule is seen to be an aggregate of differently oriented granules, whose average diameter is about 0·1 mm. The portion of the nodule shown in figure 1 is at one end of the longer diameter of the section. To the left is seen a part of the pyritic core, bounded on the right by a marginal zone of pyrite enclosing quartz grains, which are in course of replacement by pyrite. Traversing the nodule from top to bottom are three well-marked veinlets of "fibrous silica." Two of them, to the left in the photograph, are very narrow. The third, to the right, is a little over 1 mm. in average breadth. The veinlets, where they meet the quartz grains, prefer to make their way, not through the grains, but along their margins. The quartz grains are traversed by occasional pyrite veinlets. To the extreme right are seen fragments of the pyrite which originally formed the outside of the marginal zone of the nodule. The pyrite, wherever it is in contact with quartz, exhibits crystalline outlines. This feature, however, is not evident in the photograph, owing to the low magnification.

In a portion of the section not shown in figure 1, and near the outside of the nodule, there is some coarse gold intercalated between the pyrite grains.

In Plate II., fig. 2 (diam. x 78) is shown a portion of the margin of a nodule similar to the last. The crystalline outlines of the pyrite at its contact with the quartz are easily seen, and the process of replacement of quartz by pyrite is more obvious than in figure 1. Lath-like sections of chloritoid wholly or partially enclosed by pyrite are numerous. Towards the top of the photograph pyrite may be seen replacing quartz along the contact of the latter with chloritoid crystals.

Still nearer the outside of this nodule, but not shown in figure 2, the pyrite becomes less continuous, and is evidently making its way along the lines of contact of the quartz grains, especially in the

Digitized by Google

neighbourhood of chloritoid. Nearer the core than the zone represented in figure 2, there can be observed a few fairly fresh crystals of chloritoid, besides small patches of quartz with sericite or talc.

Plate II., fig. 4 (diam. x 32) is a microphotograph of a section of the commonest type of nodule. It does not possess a marginal zone crowded with quartz inclusions, as in the case of those already described, and the grain of the pyrite is much finer. The inclusions of chloritoid are very distinct, and it is evident that the nodule is a replacement of quartz.

Plate III., fig. 5 (diam. x 31, nicols crossed) shows a pyrite nodule which has partly replaced the matrix, partly a quartz pebble, lying to the top of the photograph. The nodule is bordered on the top to the right, and below to the left, by a narrow band of "fibrous silica." The dark patch immediately underneath is a hole in the section. The nodule is fractured to the left, the cracks being filled with silica. Numerous small inclusions are noticeable within the body of the nodule. The quartz pebble is bordered on the extreme right by a band of sericite. Similar discontinuous bands are met with in other portions of the margin not represented in the photograph. It is evident that this sericite was in existence before the pyrite nodule was formed, for it will be observed that the latter has, to the right, replaced a portion of the quartz pebble on the one side of the band, and of the matrix on the other, the sericite remaining unaltered, as is always the case.

In Plate III., fig. 6 (diam. x 17, nicols crossed) are seen on the right portions of two pyrite nodules of flat elliptical section. One, towards the top, is on the border of a quartz pebble, which lies above it. It is traversed by a veinlet of "fibrous silica." At the acute ends of the sections of both nodules, crescent-like growths of "fibrous silica" may be observed.

The nodules in some parts of the Du Preez Series, familiarly known as "buckshot pyrites," are referred to by Messrs. Hatch and Corstorphine.[8] They differ from those just described mainly in being rudely spherical in form and in generally possessing an internal fibrous structure. Their outside surfaces have a hackly appearance on account of projecting crystals of pyrite (or marcasite), and are frequently plastered over with coarse gold. The authors just mentioned are of opinion that the nodules are composed of marcasite, presumably because of their radiate structure. They sometimes enclose crystals of chloritoid, and appear to have originated in a somewhat similar manner to the Battery Reef Leader nodules.

Besides these small bodies there are found occasionally in the banket large nodular concretions of pyrite or marcasite, with quartz and chalcedony. They are generally termed "pyrite pebbles." I obtained a cross-section of a nodule of this sort from a pebbly patch beneath the Main Reef on the face of a drive in the 13th Level of the Meyer and Charlton Gold Mine. The larger diameter of the section is about 19 cm., the shorter about 7 cm. The diameter at right angles to the wall of the drive was as long at least as the greater diameter of the section. In

[8] *Loc. cit.*

Digitized by Google

form it is a somewhat irregular flat ellipsoid. The pyrite or marcasite is largely broken up by a network of intersecting quartz veinlets. Some of the sulphide is in the form of rudely spherical nodules, with a coarse radiate structure. They vary in diameter from 7 mm. to 1 cm. They are somewhat grey in tint, and are probably composed of marcasite. Besides the quartz veins, there are present in the nodule patches of a fine quartz mosaic crowded with chloritic inclusions. This mosaic is of earlier origin than the veins.

In the University College collection there is a large fragment of a similar but more regularly formed nodule from the Ferreira Gold Mine. The two diameters of the cross-section are about 16 cm. and 11 cm. respectively.

There is little doubt that such nodules have been formed by replacement of the banket.

Small irregular patches of pyrite are of common occurrence in the banket. In every instance in which I have examined these microscopically, I have found unmistakable proofs that they are replacements of quartz.

Plate III., fig. 7 (diam. x 20) is a photograph of part of such a pyrite patch from the Rose Deep Gold Mine. The pyrite in the section is well crystallised, the average diameter of the crystals being about 0·5 mm. At some places they are packed close together, and there they enclose abundant fresh chloritoid crystals. At other parts, such as that photographed, where there is little chloritoid, the pyrite is in less quantity, and the rock can be seen to be a quartzite. The original quartz grains are marked off from the binding material. The pyrite crystals replace the original quartz grains and cementing material alike. Thin veins of finely crystallised pyrite are seen spreading from the large pyrite crystals in between the quartz grains, and apparently along irregular cracks in these. From the distribution of the chloritoid and the pyrite in the section it is evident that the pyritisation has been greatest where the chloritoid was most plentiful.

In the nodular rock of the Battery Reef Leader, irregular aggregates of pyrite are very common, and the same affinity of the pyrite for the chloritoid is very noticeable. Plate III., fig. 8 (diam. x 78) illustrates this very well. Pyrite is seen as a replacement of the quartz within the interstices of a nest of chloritoid. No replacement of chloritoid by pyrite has taken place, the occasional ragged outlines of the former mineral being due to a previous partial replacement by quartz.

I have already referred to a portion of the Main Reef of the Geldenhuis Main Reef Gold Mine, in which most of the pyrite is beautifully crystallised. The pyrite crystals appear to have originated at different points in the quartz cement, but a considerable fraction of their growth has been at the expense of the primary quartz grains. Not only do they penetrate these, but also the larger pebbles. In Plate IV., fig. 9 (diam. x 87), which represents a portion of this rock, there is shown an occurrence of pyrite which will convince anyone that the above interpretation of the phenomena of this rock is correct. It is sometimes difficult to prove to one unaccustomed to distinguish between the primary

Digitized by Google

and secondary quartz of the banket, that the inclusion of pyrite in a quartz grain is due to replacement by the former mineral, and not to growth of the quartz grain with envelopment of the pyrite. Here some crystals of an aggregate of pyrite are seen penetrating the quartz of a pebble of quartz-tourmaline rock, already described. On account of the exceptional composition of the pebble there is no difficulty in noting the original clear cut boundary of the pebble, and it is obvious that no secondary enlargement of the pebble has taken place.

The determining cause of the replacement of quartz at certain points by pyrite is generally not apparent. Fragments of very fine-grained silicious rocks are specially liable to this alteration. In a slide (No. 82) of banket from Rietfontein "A" Gold Mine there is a section (4 x 6·5 mm.) of an irregular fragment of banded slate, of the Hospital Hill slate type, which has been completely pseudomorphed by pyrite. The original banding is perfectly preserved, the minute inclusions in the quartz of the original rock (to which the banding is due) remaining enclosed without change of place in the replacing pyrite. The latter mineral, when viewed by reflected light, is seen to be coarsely crystalline, the crystallisation having no relation to the original banding.

In one of my sections of the Battery Reef Leader of the Lancaster West Gold Mine there is seen a somewhat similar occurrence. The lamination, however, is indicated in this case by a series of straight parallel lines of inclusions of secondary quartz.

Small cherty patches containing well crystallised pyrite, and of secondary origin, are common in the banket. Such occurrences are seen in sections 61-64 of the South Reef of the Robinson Gold Mine, sections 68-69 of the Randfontein Leader of the Porges Randfontein Gold Mine, and sections 90-91 of the South Reef of the Roodepoort Central Deep. Under the microscope, the cherty material is seen to be a fine mosaic of quartz, with a finely columnar variety of the same mineral and occasionally some chalcedony. The quartz encloses crystalline aggregates or isolated well-formed crystals of pyrite, which are sometimes traversed by quartz veinlets.

In Section 90 a further replacement of the secondary quartz and chalcedony by pyrrhotite has occurred (see Plate IV., fig. 10). These patches may be due to re-crystallisation of the original rock with little or no accession of material, the pyrrhotite excepted.

Pyrrhotite.—Becker[9] states that in the mines pyrrhotite is found only in association with quartz veins. This mineral, however, is of wider occurrence. In Sections 90-91, just mentioned, pyrrhotite is fairly common. It occurs in amoeba-like patches which have obviously replaced quartz and chalcedony (see Plate IV., fig. 10). It encloses grains of pyrite. In the auriferous pyritic quartzite of the Meyer and Charlton Gold Mine (13th Level W. of cross-cut) pyrrhotite patches, the largest of which are about 3 mm. in diameter, are very common, and can easily be observed in hand specimens. They occur not only in the

[9] *Op. cit.*, p. 168.

Digitized by Google

pyritic bands, but also in the non-pyritic rock. They have the same form as in the last case, occasionally enclose pyritic grains, and are plainly late replacements of quartz. I have also found the mineral in a much sheared quartzitic rock, obviously of sedimentary origin, from the 1,000 feet level of the Simmer and Jack Gold Mine, and apparently regarded there as an "interbedded dyke."

Gold.—While studying the occurrence of pyrite in the banket, I was struck by the fact that all the microscopic sections in which I observed the occurrence of coarse gold showed distinct evidence of replacement of quartz by pyrite. I have already mentioned (p. 22) the occurrence of coarse gold in the marginal portion of a pyrite nodule which has replaced quartz. This gold has all the appearance of having been deposited during the growth of the nodule. The pyrite nodules of the Du Preez Series are, as previously noted, frequently plastered over with coarse gold. There occur also in this rock many small irregular aggregates of pyrite which are obviously replacements of quartz, and hackly grains of coarse gold are fairly common. In a section (No. 85) of the South Reef of the Geldenhuis Main Reef Gold Mine replacement of matrix and pebbles by pyrite is evident, and at the same place there is a considerable quantity of coarse gold. The largest grain that I observed in this section is about 0·2 mm. in diameter. Neither here nor in any other section did I observe any distinct crystals of gold. The metal is generally in grains of irregular form, with a hackly surface. It is sometimes intergrown with pyrite, or lying on the surface of grains of this mineral, but more frequently it is embedded in the secondary quartz of the matrix, though in this case it may be in contact with pyrite lying outside the plane of the section. The gold occurs similarly to this in several sections of the pyritic quartzite from the Meyer and Charlton Gold Mine, where, as I have previously stated, there has been considerable replacement of quartz. I might mention here that in a concentrate of zircon, ilmenite, and gold, which I obtained from a crushed portion of this rock, and from which the pyrite had been dissolved, I observed under the microscope grains of gold, which must have been attached formerly to pyrite crystals, and which retained distinct impressions of the striations which are so typical of the faces of pyrite crystals.

From the association of coarse gold with pyrite replacing quartz, I am much inclined to believe that corresponding to the two generations of pyrite in the banket are two generations of gold, of which the coarse gold is the later.

Gold Telluride.—In samples from Rietfontein of a heavy powder, mainly made up of the iridosmine already described (pp. 17-18), I found, on microscopic examination, minute clumps of crystals of an opaque bronze-yellow mineral having a bright metallic lustre. The longest diameters of the largest crystal clumps that I observed were about 0·3 mm., the crystals themselves being generally very minute. The

Digitized by Google

appearance of the clumps suggests that they occur as minute druses in the rock.

The mineral easily breaks up on pressure to hackly fragments of the same bronze colour as the crystal faces. On heating it to redness there are left slightly spongy pseudomorphs of a light-yellow gold. I have not yet had an opportunity of investigating this mineral more closely, but to judge from the properties mentioned, it is probable that it is a telluride of gold. On mentioning this occurrence to Mr. S. Ryan, he informed me that some years ago he had in his possession a piece of massive grey telluride from Rietfontein.

Calcite.—In the Meyer and Charlton Gold Mine there is a very large body of banket and quartzite, in which the quartz has been wholly or partially replaced by calcite, the pyrite remaining unaltered. A brief note on this occurrence was read before this Society by Dr. J. Kuntz[10] in 1903. While examining this portion of the mine about two years ago, I noticed in a portion of the "reef" outside the calcified body, calcification in progress for about an inch on either side of narrow fissures, from which water was issuing. Dr. Kuntz refers in his paper to a "break" from which a more extensive calcification had proceeded. There is little doubt that the whole of the calcified rock has been produced in the manner indicated by these instances.

Thin sections of this rock, microscopically examined, reveal that the replacement of the quartz by calcite is quite irregular. The alteration of the pebbles naturally proceeds from without inwards, and more rapidly along cracks than elsewhere. The replacing calcite is coarse grained, and shows frequent and well-marked lamellar twinning. Several individuals of calcite may replace a single individual of quartz, and on the other hand, several individuals of quartz may be replaced by a single individual of calcite. In the replacement of the matrix the calcite grains formed are generally smaller than in the pebbles. In sections which show remnants of unaltered quartz within the pebbles no quartz appears in the matrix.

The grains of unaltered pyrite are sometimes partially or wholly enclosed in calcite, but more generally they are surrounded by a mixture of chlorite and sericite. The latter minerals are abundant in the altered matrix, frequently occurring in large irregular patches. They probably have resulted in part from the alteration of chloritoid. Occasional grains of pinkish zircon occur associated with the pyrite and the hydrous silicates just mentioned (see Plate IV., fig. 11).

A section of calcified banded pyritic quartzite which I examined resembles more or less the matrix of the altered banket. In the pyritic bands there is an abundance of chlorite, with a little sericite, and an occasional grain of zircon. In the non-pyritic portions large individuals of calcite have each replaced groups of quartz grains, the original outlines of which are still roughly indicated by lines of chlorite enclosed in the calcite.

---

[10] *Trans. Geol. Soc. S.A.*, vol. vi., pt. iv., p. 74.

Digitized by Google

I am informed that the calcification of the banket has had no appreciable effect on the gold content.

Coating the walls of one of the old drives in this portion of the mine, there are numerous small well-formed crystals of gypsum, produced, doubtless, by the re-action of the products of oxidation of the pyrite locally or elsewhere with the calcite of the rock or waters charged with calcium carbonate.

Chlorite.—In the rock just described there is evidence of a small amount of replacement of quartz by chlorite (see Plate IV., fig. 11). This alteration, however, is better seen in a section of banket from the Princess Estate Gold Mine (see Plate IV., fig. 12, diam. x 33). The alteration of quartz to chlorite is at the junction of the banket with a small igneous intrusion. Partial replacement of the margins of quartz pebbles by sericite is a fairly common feature of the banket.

Solution of Quartz.—A good instance of solution of quartz without replacement is afforded by samples of the Main Reef, which I obtained from the 2,300 ft. Level stope of the Robinson Deep Gold Mine. In this rock the quartz of the pebbles and that of the matrix have alike been partially dissolved. The process of solution, as might be expected, has been most rapid along the surfaces of contact of quartz grains. The pebbles show beautifully etched surfaces, and in places, a highly porous structure. The matrix, where it has been most exposed to the action of the solution, has been reduced to a feebly coherent sandstone, in which the pyrite grains are laid bare. The latter mineral shows no signs of alteration.

Recapitulation.—To summarise, the main feature of the banket which the foregoing notes are intended to bring out is, that there have been at least *two periods of pyrite precipitation* in the history of the rock. The first, and much more general, precipitation occurred during the cementation period. The second was subsequent to that period, and, though of considerable importance and widespread, was determined by local causes, the nature of which is not yet clear.

It is probable that, corresponding to these, there were two periods of gold precipitation. The recognition of these two periods may lead to a satisfactory explanation of some of the remarkable local variations in the grade of the ore observed in individual mines on the Rand.

Other post-cementation processes, besides the replacement of quartz by pyrite, to which I have called attention, are the replacement of quartz by pyrrhotite, by calcite, and by hydrous silicates; the re-crystallisation of quartz and pyrite; the solution of quartz without replacement, and the late precipitation of silica in cracks.

Attention has been drawn to the alterations which the chloritoid has undergone, without a knowledge of which it is impossible to understand aright the micro-structure of the banket as we now find it.

The rare occurrence of iridosmine and telluride of gold has also been described.

Digitized by Google

Description of Microphotographs.

Plate II.

Fig. 1.—A marginal portion of a pyritic nodule from the Battery Reef Leader, Lancaster West Gold Mine. Micro-section No. 72; diam. x 17; nicols crossed. (See p. 22.)

Fig. 2.—A portion of the marginal zone of a pyritic nodule from the same locality. Micro-section No. 116; diam. x 78. (See p. 22.)

Fig. 3.—A roughly transverse section of the "fibrous silica," bordering a pyritic nodule, from the same locality. Micro-section No. 115; diam. x 162; nicols crossed. (See p. 18.)

Fig. 4.—Banket containing a pyritic nodule, from the same locality. Micro-section No. 112; diam. x 32. (See p. 23.)

Plate III.

Fig. 5.—Banket containing a pyritic nodule, which has partly replaced a quartz pebble, from the same locality. Micro-section No. 22; diam. x 31; nicols crossed. (See p. 23.)

Fig. 6.—Banket, showing part of two pyritic nodules, from the same locality. Micro-section No. 24; diam. x 17; nicols crossed. (See pp. 23 and 18.)

Fig. 7.—Quartzite, partly replaced by pyrite, from the Rose Deep Gold Mine. Micro-section No. 88; diam. x 20. (See p. 24.)

Fig. 8.—A clump of chloritoid crystals, in the interstices of which pyrite has replaced quartz, from the Battery Reef Leader, Lancaster West Gold Mine. Micro-section No. 23; diam. x 78. (See pp. 24 and 19.)

Plate IV.

Fig. 9.—Banket, showing, above to the right, portion of a pebble of quartz-tourmaline rock, on the lower margin of which a few crystals of pyrite have replaced the quartz. From the Main Reef, Geldenhuis Main Reef Gold Mine. Micro-section No. 51; diam. x 87. (See pp. 24 and 17.)

Fig. 10.—Banket, showing a quartz pebble partially replaced by fine-grained quartz, chalcedony and pyrite; also a subsequent replacement of the two first-mentioned minerals by an amoeba-like aggregate of pyrrhotite. The grains of pyrite enclosed in the pyrrhotite cannot be seen in the photograph. From the South Reef, Roodepoort Central Deep Gold Mine. Micro-section No. 90; diam. x 17; nicols crossed. (See p. 25.)

Fig. 11.—Partially calcified banket, showing two quartz pebbles. One occupying the right top half of the photograph is considerably altered to calcite, within which mineral there still

Digitized by Google

remain some remnants of the original quartz. The other, to the left at the bottom, is replaced round its margin by chlorite and sericite. Between the two pebbles is a portion of the matrix of the banket now composed of calcite, chlorite, sericite and pyrite. From the Meyer and Charlton Gold Mine. Micro-section No. 97; diam. x 18; nicols crossed. (See p. 27.)

Fig. 12.—Banket, in which the quartz is being replaced by chlorite, from the Princess Estate Gold Mine. Micro-section No. 162; diam. x 33. (See p. 28.)

INDEX TO LETTERING ON PLATES II., III., AND IV.

q = quartz.
p = pyrite.
t = tourmaline.
c = chlorite.
s = sericite.
ph = pyrrhotite.
cl = chloritoid.
ca = calcite.
fs = "fibrous silica."
qp = quartz pebble.

Digitized by Google

Note on the Correlation of the Bushveld Sandstone Series and the Overlying Volcanic Rocks (Read 27th May, 1907).

By H. Kynaston,
Director of the Geological Survey of the Transvaal.

(Communicated by permission of the Minister of Mines.)

It is only recently that the sandstones of Buiskop, near Warmbaths, and the Springbok Flats have been described in detail, and recognised as belonging to the upper portion of the Karroo System, as developed in the Transvaal.[1] The same sandstones were also found above the Coal-measure Series at Komati Poort,[2] and a series of red marls and sandy shales were detected between them and the coal-bearing rocks, both at Komati Poort and in the Bushveld. For this succession of red marls, shales, and the overlying fine-grained sandstones, the term *Bushveld Sandstone Series* was adopted.[3] This series is overlain by the amygdaloidal basalts of the Springbok Flats and Komati Poort, and varies in approximate thickness from 300 feet in the Eastern Low Veld to at least 800 feet in the Central Transvaal. It constitutes a distinct and important member of the Karroo System.

In the Report of the Geological Survey for 1905, attention was drawn to the very striking parallel between the succession in the Transvaal Bushveld and that of the Red Beds, Cave Sandstone, and Volcanic Group of the Stormberg Series of the Cape Colony, but definite correlation was not considered advisable without more reliable evidence, such, for instance, as palæontological data might supply, or a direct comparison of the beds of these widely separated areas in the field.

---

[1] See Mellor, "The Sandstones of Buiskop and the Springbok Flats," *Trans. Geol. Soc. S.A.*, vol. viii., p. 33.

[2] Mem. Geol. Survey Transvaal, No. 2, "The Komati Poort Coalfield," pp. 8 and 28.

[3] Report Geol. Survey Transvaal for 1905, pp. 12 and 16.

Digitized by Google

During last month I had the opportunity of making an examination of the Stormberg Beds in the north-eastern portion of Cape Colony, and gave special attention to the admirable sections of the Red Beds, Cave Sandstone, and Volcanic Group, exposed in the immediate neighbourhood of Lady Grey, near Aliwal North.

As one travels from Aliwal North eastwards towards the spurs of the Drakensberg, one ascends gradually through the upper portion of the Burghersdorp Beds, at the top of the Beaufort Series, and traverses a somewhat monotonous stretch of country occupied by the Molteno Beds, and chiefly characterised by long lines of flat-topped hills, terraced by successive krantzes of grit, sandstone, and dolerite. The Red Beds commence about two miles west of Lady Grey, and the village itself lies in a narrow valley, enclosed by steep slopes of Red Beds, capped by Cave Sandstone. All the higher portions of the mountains east of Lady Grey consist of basic volcanic rocks, which rise to over 3,000 feet above the level of the village, and the whole succession has a gentle dip to the south-east. The deeply dissected character of the western edge of the plateau affords numerous and instructive sections of the beds below the volcanic rocks, the fine krantz of the Cave Sandstone forming the most conspicuous feature of the district.

The best points for an inspection of the sandstone are the upper portions of the steep ridges overlooking Lady Grey from the north and south, and the narrow gorge which has been cut deeply into the formation on the east. The section on the north side deserves a short description. The main bed of the Cave Sandstone is found here at about 540 feet above the village, and is underlain by a few feet of soft reddish sandy shales. It forms a perpendicular and sometimes slightly undercut krantz, rising in a sheer wall of about 80 feet in height, with well-marked vertical jointing, but without any sign of bedding planes. The undercutting of the lower portion is often very well marked, and thus tends to form hollows, rock-shelters, and shallow caves. Above the krantz, the sandstone is continued over a steeply sloping surface, above which it occupies the entire plateau-like summit of the ridge. At the eastern end of the ridge it is overlain by the volcanic rocks.

Even a superficial examination of the Cave Sandstone vividly recalls the Bushveld Sandstone of the Transvaal, but more thorough observations of the best exposures on krantz, slope, and plateau soon satisfied me that in every respect the one is the counterpart of the other. On the summit of the ridge just described, the resemblance is brought out in a most striking manner by the fact that the nature of the surface now affords a comparison under similar general conditions of outcrop. Every detail in the peculiar and characteristic weathering of the Transvaal rock is here repeated. We have the same hummocky and boulder-like masses, the rock surface being often corrugated and pitted, or weathered, so as to resemble sun-cracking. Basin-shaped hollows, or pseudo-potholes, are often found on the upper surface, a feature also frequently observed in the Bushveld Sandstone near Komati Poort, and on the lower slopes of Buiskop. There is the same development of all kinds of strange forms, so characteristic of the sandstone kopjes of the Springbok Flats, and the same tendency to the formation

Digitized by Google

of isolated rock-pillars and fantastic monoliths. Rudely oval or spherical concretions are also sometimes found, consisting of a hard quartzitic shell surrounding a softer interior, and resemble those observed in the Bushveld Sandstone on the Crocodile River, near Komati Poort.

On this side of Lady Grey the Cave Sandstone attains an approximate thickness of 400 feet. Although its lower portion is exceedingly massive, and apparently unbedded, a rude stratification is often clearly visible in the upper portion, and false-bedding was noticed at more than one horizon. The Bushveld Sandstone has the same massive character, being only bedded on a large scale, and shows the same tendency to split up along vertical joints. A slight degree of false-bedding has also been observed in it on Zebedela's Location.

Further, in their petrological characters, the Cave and Bushveld Sandstones are practically identical. They both have a very fine-grained and uniform texture, and vary in colour from white to pale yellow and cream colour, while pink, red, and greenish grey varieties are by no means uncommon. Under the microscope, the close resemblance between the two rocks is still maintained, though in the Bushveld Sandstone there is often more distinction between grains and matrix. Both rocks consist largely of quartz grains, which are for the most part angular and very uniform in size, though a certain proportion of well-rounded grains also usually occur. Felspar is common, and includes plagioclase, microcline, and probably also orthoclase. Grains of zircon are also present. The proportion of matrix varies, and appears to be higher in the rather finer-grained varieties from the Springbok Flats, and lower in the sandstone from the Bushveld, west of Warmbaths, while in the Cave Sandstone from Lady Grey the amount of matrix is very small. Small grains of brown tourmaline are also occasionally present in both rocks, but I did not observe any hornblende or white mica in either rock—these minerals being recorded by Mr. Schwarz from the Cave Sandstone of the Matatiele division in Griqualand East.[4]

From the above considerations, it must be acknowledged that the resemblances, both general and particular, between the Bushveld and Cave Sandstones are remarkably close, and almost sufficient in themselves, in view of the somewhat special characters of both rocks, to warrant correlation between them. But if these resemblances are taken in connection with the stratigraphical evidence, I am personally of opinion that correlation is no longer avoidable. Although this evidence has already been referred to,[5] for the purpose of this paper, however, it will be convenient to consider it again briefly, as follows:—

In the Cape Colony the Cave Sandstone is overlain by a great thickness of basic volcanic rocks of basaltic type, and is underlain by the Red Beds, a series of red, purple, and greenish, sandy shales, marls, and mudstones, alternating with a varying number of yellowish, and sometimes reddish, sandstones. This series varies very much in thickness, being at Lady Grey some 600 feet thick, but in Matatiele dwindling

[4] Annual Report Geol. Comm. C.C. for 1902, p. 96.

[5] Mem. Geol. Survey Transvaal, No. 2, p. 32; and H. Kynaston, "Geology of the Neighbourhood of Komati Poort," *Trans. Geol. Soc. S.A.*, vol. ix., p. 26.

Digitized by Google

down to 200 feet. The yellowish sandstones are intermediate in character between the grits of the Molteno Beds and the Cave Sandstone, and at Lady Grey appear to become gradually finer-grained, as one ascends in the series.

In the Transvaal the Bushveld Sandstone is likewise overlain by a very great thickness of basaltic lavas, which attain several thousand feet at Komati Poort, and underlain by a series of red, purple, and greenish sandy shales and marls. These latter are exposed near Komati Poort, and they may also be seen in the core brought up from the borehole on the farm Ludlow, on the Springbok Flats. The only difference between these beds and the Red Beds is that, so far, no intercalated yellow sandstones have been observed in them. Their thickness is about 200 feet on the Springbok Flats, but probably less than 100 feet at Komati Poort.

The volcanic rocks, which overlie the Bushveld Sandstone, are of the same type as those of the Drakensberg, and both show occasionally the characteristic "pipe-amygdaloid." At Komati Poort, however, they probably attain a greater thickness than the Drakensberg lavas, and are succeeded by the acid flows of the Lebombo Range, which are followed by a further succession of basic rocks in the Portuguese Territory further east. Further, the resemblance has already been pointed out between the intrusive rocks associated with the Stormberg Series of Cape Colony and those associated with the Karroo System in the Transvaal.*

These facts are sufficient to show that the essential features of the stratigraphical relationships of the two rocks are the same, and, taken in connection with the lithological resemblances already detailed, also constitute sufficient evidence, in my opinion, to warrant the conclusion that the Bushveld Sandstone Series and overlying amygdaloids of the Transvaal are the equivalent of the Red Beds, Cave Sandstone, and Volcanic Group of the Stormberg Series of the Cape, the Orange River Colony, and Natal.

It is certainly unfortunate that decisive palæontological evidence—that great want of Transvaal geology—is in this case not yet forthcoming. In the borehole core from the Springbok Flats a single specimen of what is most likely an Estheria was found by the late Mr. Dance, when geologist to the Irrigation Department, but I am not aware of any similar occurrence in the Cave Sandstone. Above the Molteno Beds, very few Stormberg fossils have been recorded at all, though some reptilian remains are known from both the Red Beds and Cave Sandstone. It is to be hoped, however, that before long further finds will be made in the Transvaal, which will further add to our knowledge of the Karroo System.

With regard to the nature of the Cave Sandstone—a subject of some discussion among Cape Colony geologists—I could see no evidence, during my examination of it, for regarding it as being of the nature of a semi-volcanic deposit, such as a tuff or mud-flow. On the contrary, its very uniform texture and composition and extensive distribution would seem to be opposed to this view, and in favour rather of normal

* Mem. Geol. Survey Transvaal, No. 2, "Komati Poort Coalfield," pp. 44 *et sqq.*

Digitized by Google

sedimentation under tranquil conditions. The absence of bedding is no doubt only apparent, and due to continuous and uniform deposition, depending upon an extensive supply of a uniform material, such, for instance, as the older granite. This would account for the absence of lamination, due to variations in texture and composition. Moreover, false-bedding is sometimes present, though only visible on the weathered surface, and at least the upper portion of the formation has often a distinctly bedded appearance when viewed from a distance.

Note.—In connection with my examination of the sections at Lady Grey, I must express my indebtedness to Mr. A. du Toit, of the Geological Commission of Cape Colony, for helpful suggestions, and for the valuable information contained in his excellent description of the area visited, published with the Annual Report of the Geological Commission for 1904.

Digitized by Google

Note on the Field Relations of the Transvaal Cobalt Lodes (Read 27th May, 1907).

By E. T. Mellor.

(Communicated by permission of the Minister of Mines.)

The occurrences of cobalt ores in the Transvaal, at the Kruis River and at Balmoral, have received attention at various times from many geologists, particularly from Oehmichen.[1] A summary of most of the views which have been expressed, together with additional descriptions of specimens from both localities, have been recently communicated to this Society in a valuable paper by Professor R. Beck, of Freiberg.[2] A striking point brought out in this paper is the marked difference of opinion expressed by different authors as regards the nature both of the country rock and of the lodes themselves. From the references to the Transvaal cobalt lodes in his recently-published work on ore deposits,[3] and from his note just referred to, Dr. Beck evidently regards the nature of these lodes as not yet satisfactorily settled, and he invites renewed enquiry into the interesting problems presented by them, suggesting that only field work can decide the points in question.

The following notes on the mode of occurrence and the geological surroundings of the cobalt lodes have been written in the hope that they may be of help in clearing up some of the doubtful points to which attention has been drawn in Professor Beck's paper. The position and general geological environment of the Kruis River and Balmoral lodes are shown

[1] "Goldhaltige Kobaltgänge in Transvaal," *Zeitschrift für Praktische Geologie*, 1899, pp. 271-274.

[2] "Note on the Cobalt Lodes of the Transvaal," *Trans. Geol. Soc. S.A.*, vol. x., 1907, pp. 10-12.

[3] "The Nature of Ore Deposits," translation by Wied, New York, 1905, p. 346.

Digitized by Google

on the sketch map which accompanies the writer's description of the Middelburg district which follows this paper.

THE KRUIS RIVER COBALT LODE.

The country rock of the Kruis River lode has been described as an aplite[4]. An examination of specimens taken from the lode alone, both hand specimens and micro-slides, would certainly lead to this conclusion. A study of the lode taken in conjunction with its surroundings leads, however, to a different view of the character of the rock immediately associated with the cobalt ore. This appears to have been originally a felspathic sandstone or quartzite, which has been altered and partially re-crystallised by contact with a very extensive igneous intrusion which immediately overlies it.

The quartzites with which the lode is associated are thick-bedded, yellowish or pinkish-white in colour and of medium grain. Between the quartz grains there is usually visible to the eye a considerable amount of interstitial felspathic material which gives the quartzites their pink coloration. In general appearance the rocks are very similar to the quartzites of the Pretoria Series, to which they most probably belong. In the next valley to the north similar quartzites are associated with shales of Pretoria type. The quartzites in which the cobalt lode occurs are not less than 200 feet in thickness, and form a high ridge rising some 500 feet above the valley of the Kruis River, towards which they dip at an angle of 50°. The quartzites are in contact with a very extensive intrusion of basic igneous rock, which directly overlies them, and extends laterally, parallel to the quartzites, for a distance of many miles, forming the floor and lower slopes of the valley of the Kruis and Selons Rivers, the junction of the igneous with the sedimentary rocks below being parallel to the bedding planes of the latter. The width of outcrop of the igneous rock corresponds nearly with that of the valley, and opposite the cobalt mine it is not less than half a mile, and in other places much greater. In most places where it is exposed the igneous rock, which varies somewhat in composition, is coarse in texture and is best described as a gabbro. A specimen taken from an outcrop on the slopes just below the mine is a coarsely crystalline rock composed of light grey plagioclase, greenish-black augite, and a little magnetite. A micro-slide shows plagioclase, almost colourless augite, with occasional diallagic structure, and magnetite. Near its contact with the quartzites at the mine the gabbro becomes much finer in texture and darker in colour. Immediately above the sedimentary rocks it has a platy structure with the joint planes parallel to the upper surface of the quartzites. Specimens from a shaft sunk on the junction are very fresh, and this portion of the rock near the contact is best described as a dolerite. It is a holo-crystalline dark grey rock of medium texture, composed of lath-shaped idiomorphic plagioclase felspars, pale green augite, and a little magnetite. In places coarse dark mica occurs abundantly near the contact. The hand specimen shows also a few minute specks of a deep yellow mineral, pro-

[4] "A System of Mineralogy," New York, 1900, p. 260.

Digitized by Google

bably chalcopyrite. This rock is stated by Mr. Smit, who opened up the workings, and has been associated with the property for many years, to contain smaltite, but we were not able to find any specimens showing this on the occasion of my visit.

The cobalt, in the form of smaltite, occurs at, or near, the junction of the quartzites and the basic intrusion. In the best exposure it forms a fairly well defined vein from ¼-inch to ½-inch in thickness, lying 2 feet from the junction plane and parallel to it and to the bedding planes of the quartzites. In this vein, the smaltite forms a mass of coarse crystals (cubo-octahedrons) up to ⅛-inch in diameter. Minor veins occur parallel to the largest, and smaltite is also thickly disseminated for ½-inch on each side of the vein, and more sparsely throughout the rock between it and the junction plane. Up to within a few inches of the thickest vein the quartzites differ very little from those exposed over the whole hillside. They show clear bedding planes, and also a parallel banding dependent upon slight differences in the coarseness of the constituent quartz grains. The arrangement of the bands also shows very distinct current bedding. Within a few inches of the largest cobalt vein and 2 feet 6 inches from the contact with the igneous rock, the quartzite becomes more decidedly pink in colour as compared with the adjacent beds, and at the same time it becomes also more indurated, an effect which increases continually towards the contact. The pink coloration is due to a greater proportion of interstitial matter between the quartz grains. The rock maintains its quartzitic character quite up to the cobalt vein, but the banding becomes less and less distinct as this is approached. At the same time, very close-grained hornstone-like patches appear scattered through the more normal portions of the rock, and these are usually associated with much smaltite. There is no sharply defined boundary between the normal quartzite and the indurated rock near the contact.

Under the microscope, the quartzite taken about 3 feet from the main cobalt vein, showing the banding and current bedding above described, and quite similar in character to the beds below, is seen to consist mainly of small quartz grains, occasionally somewhat rounded, but for the most part angular or very irregular in outline. In places, the quartz grains fit so closely that no interspaces exist, but usually there is a considerable quantity of interstitial matter, the greater portion of which consists of much decomposed felspathic material with a few flakes of mica and a little chlorite. The banding of the rock is seen to be due to the alternately finer and coarser character of the quartz grains in succeeding layers, and to those consisting of the smaller grains being also richer in felspathic material. Within ½-inch of the largest vein of ore, the rock has precisely the same characters, with the exception that the banding is no longer recognisable. From this point towards the vein there is a gradually increasing tendency to the occurrence of recognisable crystalline conditions in the felspathic constituent of the rock. Individual crystals can be made out which show more and more clearly both crystal outlines and twinning-lamellæ. At the same time, the quartz grains become less numerous and occur in scattered individuals and groups. Where the smaltite is most abundant, quartz

Digitized by Google

grains are almost entirely absent, and practically the whole of the felspar shows crystalline structure, although very much clouded with minute inclusions. In the central portion of the vein, which appears to coincide with a small fissure in the original rock, parallel to the bedding of the quartzites, the smaltite occurs as crowded crystals up to ⅛-inch in diameter, sometimes showing distinct crystalline form and occupying the whole space to the exclusion of any other mineral. Beyond the irregular edges of the fissure the smaltite extends to varying distances into the country rock as a branching net-work enclosing the other constituents of the rock, or as crowded grains filling the interstices. In many cases the smaltite is associated very closely with the original quartz grains, and it frequently has the appearance of having replaced such grains, being distributed through the felspathic matrix in a manner closely resembling the original distribution of the quartz. The ore also frequently completely encloses quartz grains, the boundary between the two being very irregular. There is very clear evidence that since the deposition of the smaltite there has been a further introduction of silica. In many cases, owing apparently to slight movement, the smaltite has separated from the enclosing matrix, leaving a narrow intervening space, now filled in with quartz, which forms a clear border round a portion of the smaltite.

The evidence afforded, both by examination in the field and the study of thin sections, supports the view that the country rock of the Kruis River cobalt lode is a somewhat felspathic quartzite, partially re-crystallised by contact with the adjacent igneous intrusion, to which is also due the introduction of the cobalt ores.

An interesting point about the Kruis River cobalt lode is the occurrence of the mineral *Transvaalite* originally described from this locality. It is referred to by Dana as an oxidation product of cobalt-arsenide. It occurs at or near the surface, filling fissures in portions of the quartzites, about the nature of which there can in this case be no doubt, and this mode of occurrence strengthens the view that the immediate country rock of the smaltite veins is also an integral portion of the quartzites. Like the smaltite, the Transvaalite also carries a notable quantity of gold.

THE BALMORAL LODES.

The character and relationships of the Balmoral cobalt lodes are much more complicated than is the case with those of the Kruis River lodes.

The Balmoral lodes occur in a somewhat low-lying and flat area, about 2½ miles in length by 1 mile in breadth, situated 1 mile to the south of Balmoral Railway Station. This lower area is surrounded on all sides by much higher ground of very varied geological character, but differing considerably from the flat. On the north-east are ridges of sandstones and shales of the Waterberg formation, on the south-east the ground rises to a high "bult" of coal-measures, while the west side is bounded by rising ground composed of the Red Granite. These relationships are approximately indicated in the map accompanying Dr.

Digitized by Google

Dörffel's paper,[5] and in more detail in a map of the neighbourhood of Balmoral by the writer, published with the Report of the Geological Survey for 1903, and other subsequent maps. The occurrences of cobalt, as far as is known, are limited to the northern portion of the flat, which is crossed from side to side in an almost east and west direction by several approximately parallel lodes, which occasionally crop out a few inches above the surface, and which have been followed in numerous trenches and pits. The rock which forms the greater part of the flat, and which constitutes the country rock of the lodes, never forms any conspicuous outcrop, but is occasionally exposed in small patches, or covers the surface of the ground with its angular débris. Its true character is not easily determinable with absolute certainty, either in the field or in thin sections. In colour, it varies from light grey to nearly black, while near the lodes it is occasionally pink. It is of flinty hardness, with a splintery to semi-conchoidal fracture. When struck with the hammer, however, it rarely shows a fresh break, but parts along innumerable perfectly flat joint planes, which cross one another at all angles, dividing the rock into fragments from one inch to about one foot in diameter, bounded by perfectly smooth plane faces, and with exceedingly sharp edges and angles. In many places the rock shows no signs whatever of any stratified structure, but in others it is finely banded, and there is occasionally a tendency to part along planes parallel to the lamination. This is best seen in an exposure on the north side of the flat in the bed of the spruit near the cemetery. Dr. Dörffel speaks of the rock as a "grey dense quartzite," a description to which many portions of the rock, especially in the immediate neighbourhood of the mine, answer well. It is frequently, however, so fine in texture that such terms as flinty or cherty shale would better describe it. Many specimens suggest a very fine-grained felsite. Under the microscope, the greater part of the rock appears to consist of finely crystalline quartz, with numerous minute elongated crystals of a pale green mineral which appears to be epidote, which in some places are aggregated into small patches and bands. Taking all its characters into consideration, the most probable explanation of the nature of the rock is that it represents a series of shales grading occasionally into more sandy beds, which have been intensely indurated and to some extent re-crystallised by thermo-metamorphic action. Unfortunately, no clear evidence is anywhere presented of the relationship of the rock to any of the other sedimentary rocks in the neighbourhood. Both Molengraaff[6] and Dörffel regard it as belonging to the upper portion of the Pretoria Series, and in mapping this area the writer has also taken this view. Two small kopjes of Pretoria quartzite occur just to the north of the flat, but are separated from it by a considerable diabase intrusion, and consequently afford no satisfactory evidence. Within fifty yards of the mine, however, the ground rises into a small ridge of shale, continuous with the shales at the base of the Waterberg formation; the junction, however, of these rocks with those of the flat is not exposed,

[5] "The Balmoral Cobalt Lodes," *Trans. Geol. Soc. S.A.*, vol. vi., 1903.
[6] "Geology of the Transvaal," 1904, p. 53.

Digitized by Google

either naturally or in any of the prospecting works. The shales are here somewhat softer than the country rock of the lodes, but a little further along the ridge, near their contact with the big igneous intrusion to the east, they bear a close resemblance to that rock. Dr. Dörffel's statement that the cobalt lodes are not found to pass into the Waterberg shales is against the inclusion of their country rock in the Waterberg formation. The igneous intrusion, however, to which Dörffel ascribes the introduction of the cobalt is certainly intrusive in the Waterberg rocks, and there is an outcrop on the road running about 300 yards east of the mine of a vein carrying cobalt ore in what are almost certainly Waterberg shales, so that the evidence for the inclusion of the rock forming the flat at Balmoral in the Pretoria Series is by no means conclusive.

A number of extensive basic intrusions occur in the immediate neighbourhood of Balmoral. Of these, one which forms the low ground, along which the railway line runs, has an average width of outcrop of one mile, and is several miles in length. Near Balmoral Station this is a coarsely crystalline gabbro, with typical diallage as its ferromagnesian constituent. It frequently contains numerous large porphyritic crystals of plagioclase up to one inch or more in length. With this rock are probably connected in origin, several intrusions occurring near the cobalt mine. These crop out from the flat in several places, but the main body occurs on the north-east side, where it rises into several conspicuous kopjes below the ridge of Waterberg shales and sandstones into which it has been intruded. On the kopjes the rock is a medium-grained dark grey crystalline rock, consisting mainly of plagioclase and hornblende. Under the microscope, it shows a coarsely crystalline structure. The predominant minerals are plagioclase, green hornblende and pale augite, the two latter in about equal proportions. There are also present a little orthoclase and quartz, which in some places form a granophyric intergrowth. Magnetite is also present in small quantity. The rock is of a type very common as intrusions along the junction of the Waterberg and Pretoria Systems west of Balmoral, which vary considerably in composition within the limits of the same intrusion, ranging from gabbros to syenites. Very characteristic is the occurrence of small amounts of quartz intergrown with felspar, even in comparatively basic phases. On the lower slopes of the kopjes the rock becomes finer in texture, and more irregular in composition, and the surface weathers in a very uneven manner into pits and depressions. It penetrates the Waterberg shales, and contains brecciated fragments, apparently derived from them. This form of the rock can be seen within 400 yards of the mine shaft, and is identical in appearance also with several dyke-like outcrops on the flat. I am strongly of opinion that Dr. Dörffel was right in connecting the origin of the cobalt lodes with the basic intrusions just described, and think that Prof. Beck's description of the lodes as "mineralised dykes" is the most appropriate term which can be applied. Mr. C. B. Horwood [7] also regards the lodes as

[7] "The Red Granite of Balmoral and its Relation to the Cobalt Lodes, *Trans. Geol. Soc. S.A.*, vol. vii., 1904.

Digitized by Google

igneous dykes, but considers them to be related to the intrusion of Red Granite on the west of the flat. The contents of the lodes have already been so fully described by the authors referred to that it is unnecessary in the present note to do more than draw attention to a few points which bear upon this question of relationship to neighbouring igneous masses. It may be mentioned, however, that calcite, which has not been noted in descriptions of the lodes, occasionally occurs in crystals up to one inch in diameter. Mr. Horwood speaks of the veins as "of a decidedly acid nature," and as consisting of quartz, felspar, and probably hornblende, the relative abundance of these constituents being in the order named. The writer, however, agrees with Dr. Dörffel in regarding the quartz, or certainly the greater part of it, as a secondary mineral, and most probably a late addition to the lodes. In the lode first opened up, upon which Mr. Horwood's description was based, quartz certainly formed a conspicuous part of the gangue, but in the lodes subsequently opened up it is almost entirely absent. These veins are decidedly basic in general composition; the greater part of the gangue is composed almost entirely of dark green hornblende or actinolite, sometimes in finely fibrous form, sometimes in bladed masses, and in some of the richest specimens obtained from the mine, which consist almost entirely of smaltite, in masses up to twelve inches in diameter, the only gangue mineral seen is actinolite, with which the smaltite is closely intergrown. Felspar is also very abundant, and in the poorer veins forms the greater part of the gangue. It is usually penetrated by the amphibole, which is of earlier growth. A small barren vein, about ten inches in width, well exposed in a pit about 300 yards north of the main workings, consists for the greater part of coarse white and pink felspar, in crystals up to $\frac{1}{4}$-inch in length, with irregular bands, patches, and radiating bunches of fine needle-like crystals of actinolite. A number of smaller side-veins, usually $\frac{1}{8}$-inch to $\frac{1}{16}$-inch in width, traverse the country rock, and appear to be filled entirely with amphibole. One of these, about one inch in width, includes numerous sharply angular fragments of the country rock. It is a noticeable fact that all the igneous veins in the neighbourhood whose origin can be clearly traced to the Red Granite are of an exceedingly acid character, and conspicuously poor in ferro-magnesian minerals, as indeed is the granite itself, and in some cases the veins are composed almost entirely of quartz, with a little muscovite. This very acid character of the granite veins, as well as of various peripheral modifications of the granite mass, was noticed by Mr. Horwood in his paper on the Cobalt Lodes. It is, I think, very strong evidence against the connection of the cobalt lodes with the granite, and the absence from these lodes of minerals usually associated with the influence of intrusive granites also points to the same conclusion. The Balmoral granite mass is comparatively small in size, even compared with the basic intrusions in the same neighbourhood. Moreover, it has had very little effect upon the Waterberg beds, into which it has been immediately intruded. The close connection of the Kruis River cobalt lode with an extensive basic intrusion is a further argument for a similar origin for the lodes at Balmoral. The similarity in geological position of the lodes of Kruis

Digitized by Google

River and Balmoral will be seen from the map of the Middelburg district referred to. The field evidence therefore appears to point decidedly to the origin of the Balmoral cobalt lodes as mineralised dykes connected with a neighbouring large basic igneous mass and intruded into a series of highly altered sedimentary rocks.

Digitized by Google

The Geological Structure of the Middelburg District, with special reference to the Character, Relationships and Thickness of the Waterberg System (Read 27th May, 1907).

By E. T. Mellor

(Communicated by permission of the Minister of Mines.)

[Plate V.]

Recent survey work in the Middelburg district has brought out very clearly the character and relationships of the various divisions of the Waterberg System, and has afforded a very interesting example in tectonic geology, which gives a key to the structure of a very large part of the Middelburg district and a portion of the adjoining district of Pretoria. In particular, the extensive series of volcanic rocks forming the lower portion of the Waterberg System, to which attention was drawn by the writer in a previous paper, has been more fully worked out, and it is now possible to give an approximate estimate of the thickness of these lower beds, and to explain their relationship to the upper part of the system.

The object of the present paper is to give a brief summary of these results, the subject having been dealt with in greater detail in the forthcoming Report of the Geological Survey for 1906.

Up to a comparatively recent date, the Waterberg System was generally regarded as composed almost exclusively of sedimentary rocks, consisting for the most part of sandstones, grits, and conglomerates, with a marked absence of beds of a shaly character. The coarse conglomerates, found at or near the base of the sandstone series, were usually regarded as marking the base of the system. While this is certainly the case in some localities where the lower portion of the

Digitized by Google

system is not developed, the sedimentary beds elsewhere succeed an extensive series of volcanic rocks, chiefly acid lavas, with which the lowest strata are interbedded. In the Report of the Geological Survey for 1904, the writer described the occurrence of the Volcanic Series at Rhenoster Kop.[1] Owing to the very disturbed condition of the formation in that neighbourhood, the relationships of its various portions are not very clearly seen, and this is still more the case further west. The Volcanic Series is, however, particularly well developed in the Middelburg district, attaining a thickness of, approximately, 8,000 feet, and its conformability to the upper portion of the system is very clearly brought out by the mapping of that area, of which the general outlines are given in the sketch map accompanying this paper (Plate V.). It will be seen from this map that the rocks of the Waterberg System in the Middelburg district occupy at the surface a very extensive area, roughly oval in shape, with a shorter diameter of approximately thirty miles. On the south and east, the same system extends considerably beyond the limits shown on the surface, being there hidden by a comparatively thin covering of Karroo rocks. The central portion of this Waterberg area is occupied by a series of red and purple sandstones, grits, and conglomerates, well known to those who are acquainted with the Waterberg System. This series of sandy sediments was formerly regarded as representing practically the whole of the Waterberg rocks, and this view appeared the more likely as the lowest beds were found in places to rest directly upon older rocks of the Transvaal System, or to be separated from them only by extensive intrusions of igneous rocks, the former condition being illustrated at Balmoral,[2] and the latter along the junction of the two systems further west. In the course of survey work in 1904, however, the writer found the sandstones to be underlain at Rhenoster Kop by a thick series of volcanic rocks, which represented a lower portion of the Waterberg System. This series was described in a previous paper before the Society,[3] and in more detail in the Report of the Geological Survey for 1904. In 1905, the Volcanic Series was again met with on the southern edge of the syncline, in the neighbourhood of Witbank, and was described in the Survey Report for that year. I have recently been able to connect these two occurrences—separated by a distance along the outcrop of more than 100 miles—and so to complete the delineation of the interesting fold shown on the accompanying sketch map, the details of which are given in the Report of the Survey for 1906, and in the maps which accompany it. The Volcanic Series will be seen to occupy a very large area, forming a zone completely surrounding the rocks of the upper portion of the Waterberg System. Chiefly on account of the vertical or highly inclined position of the beds, this zone is very narrow in the neighbourhood of Rhenoster Kop, and is cut out by a fault a little further east; towards the junction of the Wilge and Olifants rivers, however, it widens out considerably, owing

[1] *Loc. cit.*, pp. 48-53.

[2] E. T. Mellor, "The Waterberg Sandstone Formation and its Relations to Other Formations in the Transvaal," *Trans. Geol. Soc. S.A.*, vol. vii., 1905, pp. 7-27.

[3] "Evidence of Contemporaneous Volcanic Activity in the Lower Portion of the Waterberg Formation," *Trans. Geol. Soc. S.A.*, vol. viii., pp. 38-41.

Digitized by Google

to a much lower dip, narrowing again where it is crossed by the Olifants river just south of the farm Wagendrift (28), and along the northern limb of the syncline, where the dip is again very high, with an average of about 60°. Where the series turns southward, parallel with the valley of the Selons river, the dip falls to from 10° to 15°, and the breadth of outcrop is enormously increased, and continues very wide in the southward sweep, being certainly not less than twelve miles south of the town of Middelburg, where it is partly covered by Karroo rocks. West of this point, the outcrop narrows again, and represents the crown of a synclinal fold. The Volcanic Series must, however, form the base upon which the Karroo rocks were laid down for a considerable distance to the south-west—characteristic types being met with in several boreholes along the new Springs-Witbank line, notably on the farms Oogiesfontein (543) and Vlakvarkfontein (101). Towards Balmoral the Volcanic Series thins out, and the conglomerate at the base of the Sandstone Series comes to rest directly on rocks of older systems. On the north, and probably also on the east of the big fold just described, the Red Granite of the Bushveld has been intruded below the Waterberg Volcanic Series, which is usually underlain by the granite. Between the farms Loskop (197), to the west of Wagendrift, on the Olifants river, and Roodepoort (78), near the junction of the Kruis and Selons rivers, the Volcanic Series is underlain by basic igneous rocks, corresponding most probably to the norites and diabases found along the margin of the Red Granite in other areas. These rocks overlie quartzites of the Pretoria Series, which form high ridges on the farms Laastedrift (82), Kruisrivier (65), and Goedgedacht (194). It is interesting to note that the cobalt lodes which are found at the contact of the basic igneous rocks with the quartzites on Kruisrivier and the cobalt lodes at Balmoral, on the southern edge of the Waterberg Syncline, occur at the same geological horizon.

Owing to the frequently broken and faulted condition of the hard and brittle felsitic rocks of the Volcanic Series, which do not yield kindly to the degree of folding they have in many places undergone, it is not everywhere possible to get a good section of the whole succession, owing chiefly to the great width of outcrop of some of the individual flows and the great quantities of angular débris which they produce. The best sections are met with along the most northerly outcrop of the series, which runs almost in a straight line for many miles, forming a high range with a number of minor parallel ridges, in which, when viewed from a distance, the stratified arrangement of the rocks comes out in a very striking manner. A fairly good section is presented by the poort by which the Olifants river cuts through the series south of Wagendrift, but a still better one is obtained along a line passing almost through the middle of the farms Zekoegat (89) and Roodepoort (78), due south of the Kruis River Cobalt Mine. This section has been given in detail in the Survey Report for 1906. Its general features are as follows: The breadth of outcrop of the Volcanic Series is two-and-a-third miles; the dip, which varies little throughout the section, averages 60°. The thickness of the series, allowing for a fault which increases the thickness of the section by about 1,000 feet, and deducting the

Digitized by Google

thickness of an intrusive sheet of granite-porphyry, amounting to an additional 1,000 feet, is not less than 8,000 feet. This great thickness of rocks consists for the most part of lava flows of acid and intermediate composition. The top and bottom portions of each flow are usually vesicular or amygdaloidal, the lower portions especially showing frequent flow-structures. The central portions are often porphyritic, and in the thickest sheets frequently holocrystalline. One of the thickest of these flows occurs near the top of the Volcanic Series. The rock is a hard red, banded rhyolite, with conspicuous flow-structure. It measures 600 paces across the outcrop, and is not less than 1,000 feet in thickness. Another flow—an andesite—which occurs about the centre of the series, and is easily distinguished by its colour from the associated beds, is 900 feet in thickness. Its upper and lower portions are black and stony in appearance, with numerous small porphyritic crystals of felspar and augite, and occasional bands of amygdules, grading into a central portion, which is a massive purplish-brown rock, much more coarsely crystalline.

In the upper half of the Volcanic Series, sedimentary rocks are interbedded with the lavas on at least five different horizons. The thinnest of these occurrences consists of 6 feet of fine-grained brownish quartzite, well bedded. The thickest, which underlies the sheet of banded rhyolite above mentioned, and is itself underlain by a coarse tuff, includes 250 feet of hard flinty, flaggy shales and red fine-grained felspathic sandstones, very evenly bedded, the top 50 feet much indurated by the lava flow above. A third series of sedimentary beds, which also succeeds a bed of tuff, has at the bottom 50 feet of typical soft purple Waterberg Shales passing up into 100 feet of sandstones—purplish-brown below, yellow and quartzitic above. On the line of section, the last of the lava flows is succeeded by 250 feet of dark brown to purple sandy shales and sandstones, with pebbly bands in the upper portion, followed by a great conglomerate (160 feet in thickness), massive, with occasional indications of rude bedding-planes about 12 feet apart. The conglomerate is composed of well-rounded pebbles, averaging 6 or 8 inches in diameter, and ranging up to 12 inches, derived from the lavas below. It is followed by a thick series of soft brown and purple massive sandstones, forming the valley on the south portion of Zekoegat, and these, by the harder sandstones, quartzites, and grits of the upper part of the Waterberg System, forming the main plateau to the south.

The occurrence, between the Volcanic Series at the base of the Waterberg System, and the hard sandstones, quartzites and grits constituting its upper portion, of an intermediate type of rocks, sedimentary in origin, but composed largely of material derived from the waste of igneous rocks, is a very constant feature. Near Rhenoster Kop, this series includes shales and soft coarse brown and purple sandstones; in the northern portion of the Waterberg area, as, for instance, on the section line referred to above, it consists almost entirely of soft brown or purple sandstones, while towards Middelburg these given place to blue, black, and red slaty shales and flags, with occasional beds of hard brick-red fine-grained sandstones; the latter types being

Digitized by Google

well seen about the bridge over the Olifants river at Middelburg town. This series of shales and soft sandstones has an average thickness estimated at 2,000 feet. The transition to the upper series of hard sandstones and quartzites is usually marked by the occurrence of beds of conglomerate, which frequently attain a considerable thickness.

The various members of the Waterberg System, as developed in the Middelburg district, may be classified as follows:—

CLASSIFICATION OF THE WATERBERG SYSTEM.

			Approx. thickness feet
WATERBERG SYSTEM.	UPPER DIVISION	*Sandstone and Quartzite Series*— Sandstones, quartzites, grits and conglomerates - - - -	5,000
	LOWER DIVISION	*Shale and Sandstone Series*— Shales, soft sandstones and conglomerates - - - - -	2,000
		Volcanic Series— Lavas, tuffs, breccias and agglomerates, with interbedded shales and sandstones - - - - -	8,000

The different divisions of the Waterberg System usually give rise to distinct and characteristic surface features. Thus the upper series of sandstones forms extensive plateaux, or long parallel lines of escarpments and dip slopes according as the inclination of the beds is small or great; the volcanic rocks form lofty continuous ridges, with smooth outlines, but exceedingly rough surfaces, while the intermediate shales and sandstones usually give rise to a wide and continuous depression (see section, Plate V.). The main plateau, to the north of Middelburg, is surrounded by an escarpment, or series of escarpments, with an average height of nearly 1,000 feet, practically continuous from Klipplaatdrift, fifteen miles north of Middelburg, to Rhenoster Kop, a distance of about fifty miles. The edge of this plateau is separated from the high encircling ring of felsite ridges by the broad depression representing the outcrop of the shales and soft sandstones; and otherwise than on foot it is scarcely possible to ascend from the Bushveld to the plateau by any other route than those which pass over the flanks of Rhenoster Kop, or up the valley of the Selons river, except at one intermediate point on the farm Kranspoort (18), where a Government road has been cut. The same separation of the main Waterberg plateau from the felsite ridges by a broad depression, representing the intermediate softer sedimentary beds, occurs also in much less marked degree on the south side of the Waterberg area, between Klipplaatdrift and Witbank, the town of Middelburg standing in the

Digitized by Google

depression, which is however, as it were, bridged both to the north and south by the high bults of the coal-measures.

MUTUAL RELATIONSHIPS OF THE WATERBERG SANDSTONES, FELSITES, AND PLUTONIC SERIES OF THE BUSHVELD.

The felsites which occur over large areas in the Bushveld are generally regarded as being intimately associated with the Red Granite, and as forming with it an integral portion of the Bushveld Igneous Complex, and these felsites have not usually hitherto been regarded as being specially associated with the Waterberg System. Both the felsites and the Red Granite of the Bushveld are looked upon by some authors as distinctly older than the Waterberg System. While, however, some of the felsitic rocks of the Bushveld no doubt represent finer grained portions of the Bushveld Granite, the writer considers it very probable that in many cases they belong to the acid flows associated with the early part of the Waterberg period. Conglomerates consisting almost entirely of pebbles composed of the various types of acid volcanic rocks found among the lavas of the lower part of the Waterberg System are common among the sedimentary beds by which the Volcanic Series is succeeded. While their presence indicates that the volcanic rocks were subjected to denuding agencies, it does not necessarily involve any great difference in age. Conglomerates of this kind might be expected to occur in any area where volcanic conditions were succeeded by, or were contemporaneous with active sedimentation. In the Middelburg district such conglomerates are of constant occurrence, and while they frequently vary considerably in thickness within comparatively short distances they are markedly conformable to the remainder of the series. With regard to the relationship of the Red Granite to the Waterberg System, evidence of its intrusive character, both with regard to the felsites and to the sedimentary rocks of the Waterberg System, has previously been given by the writer in the papers already referred to. It is again particularly well shown in the district dealt with in the present paper, by the big intrusion of granite and granite-porphyry shown along the northern margin of the Waterberg area in the map (Plate V.). This intrusion, which in its coarser central portions is identical in petrological character with the Red Granite of the Bushveld, follows approximately the strike of the Volcanic Series for many miles, then breaks across it and comes into contact with the sedimentary rocks above. The phenomena shown both by the granite-porphyry itself at its margin and by the rocks with which it is in contact, leave no doubt as to its intrusive character, both with regard to the Waterberg Volcanic Series and the sedimentary beds which succeed it.

The difficulties surrounding the explanation of the apparently contradictory evidence regarding the mutual relationships of the Waterberg rocks and the Bushveld Plutonic Series have been summed up by Dr. Molengraaff.[4] Many of these difficulties disappear with the separa-

[4] "Geology of the Transvaal," Johannesburg, 1904, pp. 59-60.

Digitized by Google

tion of the Waterberg Volcanic Series from the Plutonic Series of the Bushveld, and when we realise that active volcanic conditions prevailed during the deposition of some of the early Waterberg sediments. It will be seen that the structure of the district described in the present paper fully justifies Molengraaff's conception of the laccolitic character of the Red Granite, although the roof of the intrusion must in general be taken to lie at a very much lower horizon than the base of the upper Sandstone Series.

RELATION OF THE GEOLOGICAL STRUCTURE OF THE MIDDELBURG AREA TO THAT OF THE TRANSVAAL IN GENERAL

The disposition of the strata of the Waterberg System in the form of a huge basin-like fold about Middelburg is in itself an interesting feature in the geological structure of the district. But it has also a wider significance. If the map of the area here described be placed in its proper relative position on a more general map on which are represented the main features of the geology of the Transvaal, as far as we know them at present, it will be seen that the disposition of the Waterberg System in the Middelburg district agrees in a striking manner with the wide sweep of the Transvaal System from Pretoria round the eastern escarpment of the Transvaal by Haenertsberg to near Potgietersrust. Both systems show evidence of folding on a large scale, due to pressures exerted from the N.N.W. and S.S.E. at right angles to the common axis of the basin-like folds in the Waterberg and Transvaal Systems. The participation of the Waterberg rocks in the effects of such pressures shows that these were exerted, in part at least, after the laying down of the Waterberg System. That the upper of the two systems, as might be expected, suffered the greater amount of folding and displacement is shown by the extreme inclination of the Waterberg strata along their northern margin in the Middelburg district, amounting to actual inversion at Rhenoster Kop. It is further interesting to note that the longitudinal axis of certain folds in still older formations, such as the syncline between Johannesburg and Heidelberg of the Witwatersrand System, has also the same general direction as that of the folds in the Transvaal and Waterberg Systems above referred to, pointing to an origin due to the exertion of pressures in the directions named. Again, pressures acting in the same directions would account for the prevailing strike of the planes of schistosity in the older schists in various localities, notably in the Murchison Range and the adjoining districts. These various effects have probably not been simultaneously produced; they point to the recurrence over a very long period of time, but in a more or less constant direction, of the action of forces which have played a very important part in determining the present geological structure of the Transvaal.

Digitized by Google

The Marginal Phenomena and Geological Relations of the Granite north of Johannesburg (Read 24th June, 1907).

By H. Kynaston,
Director of the Geological Survey of the Transvaal.

(Communicated by permission of the Minister for Mines.)

[Plate VI.]

I. INTRODUCTORY.

During part of November and December of last year I was engaged upon the mapping of the southern portion of the area occupied by the granite north of Johannesburg. In the course of the work special attention was given to the southern and south-western boundary of the granite, and to the collection of all available evidence bearing upon the relations between this extensive igneous mass and the various rocks with which it is found in contact, and it is this question which I propose to deal with in the present communication.

By far the larger portion of the area, which is represented upon the accompanying map, is occupied by the granite, while small areas to the north and east of Krugersdorp and west of Zuurfontein Station are characterised by a series of basic rocks, consisting mainly of amphibolites and serpentine. The only sedimentary rocks, exclusive of the Witwatersrand System, which are found in the area, consist of two small patches of the Moodies Series (Swaziland System), lying between Zwartkop and Krugersdorp, and a small portion of ground covered by Ventersdorp beds to the south-west of Zwartkop. Volcanic rocks of Ventersdorp age are seen in the south-east portion of the area, where they form part of the belt which stretches from the Bezuidenhout Valley in a north-easterly direction, crossing the railway a short distance south of Zuurfontein.

Digitized by Google

Dyke-like intrusions of diabase and diorite are common in many parts of the area, and are of later date than the Witwatersrand System.

Before we consider the granite, a brief account of the rocks here included in the Swaziland System will be necessary, as their presence is so closely connected with some of the marginal phenomena of the granite.

II. THE SWAZILAND SYSTEM.

(1) *Moodies Series.*—The principal occurrence of the Moodies Series in this part of the country has been mapped by Mr. A. L. Hall on the farm Zwartkop No. 82.[1] The additional occurrence here recorded forms two small oval patches, which together constitute a slight ridge-like feature on the north-eastern portion of the farm Honingklip No. 72, three miles west of Mulder's Drift.

The outcrops consist of shales and quartzites, and are surrounded by basic schists and granite. The beds, unlike those of Zwartkop, have a general east and west strike, though this is by no means uniform. The general direction of dip is to the south, and it is invariably at a high angle. The whole behaviour and condition of the rocks indicate that they have been subjected to considerable disturbance and mechanical strain. They are everywhere highly sheared, the shales being frequently contorted, and showing a well-marked schistose structure.

The quartzites occur in two well-marked, though narrow, bands of no great thickness, and alternate with reddish, dark grey and greenish indurated shales. They are pale yellowish to white in colour, fine-grained, tough and compact, and resemble portions of the middle quartzite of the Zwartkop ridge.

The shales strongly resemble those of Zwartkop. They have been much altered and sheared, and are occasionally contorted and crumpled, though on a small scale, the contortions being well illustrated by a set of small quartz veins, which have been folded up into a series of sharp S-shaped folds, together with the surrounding schists. The quartz of these veins has at the same time apparently undergone a re-crystallisation, and now shows a crystalline granular structure.

(2) *Associated Igneous Rocks.*—A series of basic schists and serpentines are well developed in different parts of the area. There is good evidence, however, that they are older than the granite, and they appear to be so intimately associated with the sedimentary rocks just described that it seems advisable to include them here in the Swaziland System. Similar rocks are found associated with the Moodies Series at Barberton, and Mr. Hall has pointed out that they are also seen in association with the same series below the Devil's Kantoor.[2]

In addition to this basic series, we find in the neighbourhood of Mulder's Drift, north of Krugersdorp, some highly acid rocks, which may be classed as quartz-felsites. These, again, are apparently associated

[1] See Hall and Humphrey, "The Black Reef Series and Underlying Formations in the Neighbourhood of Kromdraai and Zwartkop," *Trans. Geol. Soc. S.A.*, vol. ix., p. 10; also Annual Report Geol. Survey Transvaal for 1905, p. 71.

[2] Annual Report Geol. Survey Transvaal for 1905, pp. 55, 61 and 71.

Digitized by Google

with the basic schists, rather than with the granite, so that they will also be more aptly described among the igneous rocks associated with the Moodies Series of the Swaziland System.

(*a*) *The Basic Schists and Serpentines.*—These rocks, so far as can be seen from their distribution at the surface, attain their maximum development about the southern margin of the granite. Thus they constitute a well-marked belt between the Rand escarpment, north of Krugersdorp, and the Ventersdorp Beds on Kromdraai and Driefontein. Thence they extend to the south-east, with a gradually diminishing breadth of outcrop, which finally tapers out beneath the Lower Witwatersrand beds on the farm Weltevreden, north of Florida. From this point eastwards they are found in more or less detached masses, always near the southern boundary of the granite, the largest of these lying immediately north of the Rietfontein mines.

The distribution, therefore, of these basic rocks to a certain extent resembles a peripheral basic zone to the granite, and it is quite possible that this zone may extend in a more complete manner beneath the Lower Witwatersrand Series to the north of Johannesburg. These rocks cannot be regarded as a direct modification of the granite, as in no case can the granite be seen gradually passing into them, while, on the other hand, the injection of veins of granite into the basic schists was observed on Waterval No. 79, and in the core of a borehole put down close to the Lazaretto on Rietfontein. It is quite possible, however, that both rocks may have been derived from the same general parent magma, though we must regard the basic series as belonging to a slightly earlier period of intrusion.

The outcrops of the basic rocks show considerable variation in structure and composition. The structural variations are almost entirely the result of the pressure-metamorphism, which has affected both the granite as well as all the rocks included in the Swaziland System. We have massive serpentinous rocks, sometimes showing indications of an original very coarse structure, and without any trace of schistosity, well seen, for instance, in the rock exposed near the railway terminus at the Modderfontein Dynamite Factory—passing into amphibolites and highly-sheared actinolitic, hornblendic, and talcose schists. The more central portions of the larger masses consist usually of a massive serpentine, or a mixture of serpentine and amphibole, while the marginal portions and the smaller patches and bands are almost invariably fine-grained and highly schistose. Schistose bands frequently traverse the more massive portions, no doubt where these latter have given way along lines of weakness to the dynamic movements. Talc is often associated with these schistose bands, and the serpentine west of Mulder's Drift is often traversed by zones containing small veins of chrysotile.

A characteristic variety may be observed, where marginal portions of these basic rocks are veined by the granite, as, for instance, in the north-western portion of Waterval No. 79 and in the northern portion of Weltevreden No. 78. In these cases the rock is exceedingly hard and compact, and consists almost entirely of small idiomorphic prisms of green hornblende, without any tendency to orientation. The fact that this type is apparently confined to the immediate

Digitized by Google

neighbourhood of granite veins, and the fresh condition of the hornblende crystals, indicate that it is probably the result of contact metamorphism, the basic masses being in that case of earlier date than the granite.

The planes of schistosity in the basic series do not appear to maintain a constant direction for any great distance, both the direction and degree of inclination showing considerable variation. The general direction of strike is perhaps more commonly south-west and north-east. Near the waterfall on Roodekranz No. 89, at the foot of the Witpoortje kloof, the planes of schistosity run sometimes apparently parallel and conformable to the strike of the Lower Witwatersrand beds, but at other times, on the contrary, they are almost at right angles to it, and almost vertical. The character also of the basic schist in this neighbourhood in its occasional resemblance to a dark altered shale, might possibly mislead one to suppose, from the appearance of certain sections, that the rock was a conformable member of the Orange Grove Series; but any such idea is quickly dispelled by a more extensive survey, which shows the real character of these rocks, and proves that there is no relation whatever between them and the Witwatersrand Series, except one of very marked unconformity.

(*b*) *The Quartz-Felsites.*—The acid rocks found in the neighbourhood of Mulder's Drift resemble the basic rocks in the fact that they are partly in their original massive condition, and partly sheared and schistose. Their mode of occurrence suggests that of later dyke-like intrusions in the granite. It is difficult, however, to reconcile this with the fact that they are occasionally traversed by veins and tongues from the main mass of the granite in a highly schistose condition, such veins being well exposed about half a mile north of Mulder's Drift, and at the side of the main road on the south side of the drift. These phenomena so strongly resemble intrusive veining, rather than any effect of earth-movement or dislocation, that it seems preferable to class these acid rocks as earlier than the granite and connected with the basic schists and serpentines.

In Hatch and Corstorphine's "Geology of South Africa" (page 95), these rocks are referred to as aplites, and it is also pointed out that they have been mistaken for quartzites. There is no doubt that their general resemblance to quartzites is very great, though there is no sign of any true bedding or lamination; but a close examination soon discloses their undoubted igneous nature. In general character, however, and minute structure, a closer resemblance is found to the quartz-felsites than to the aplites.

The principal occurrence is well exposed in the bed of the Crocodile River at Mulder's Drift, and forms a dyke-like mass with a nearly north and south trend. The rock is yellowish in colour, very fine-grained, and split up by numerous more or less rectangular joint planes, which tend to accentuate the general resemblance to a quartzite. Under the microscope one sees phenocrysts of quartz, often more or less corroded, and felspar, probably oligoclase, in a micro-crystalline ground-mass, containing occasional flakes of white mica. Sometimes the matrix consists almost entirely of micropegmatite, when the rock deserves rather the name of granophyre. Sometimes the felspar phenocrysts are absent.

Digitized by Google

Some of the other intrusions, especially one associated with the Moodies Series, three miles west of Mulder's Drift, show signs of having been considerably sheared, and have evidently been affected by the same movements, which have caused the foliation and shearing of the basic igneous series and the sediments of the Moodies Series.

III. THE GRANITE.

It has been stated that the geological margin of the granite is nowhere exposed,[3] that is to say that its superficial extent is everywhere limited by more recent overlying formations. This is certainly, to a great extent, true; but the examination of the present area tends to show that at least along its south-western boundary the granite presents a distinct marginal facies; and since it has already been pointed out that the belt of basic schists there exposed is not a mere modification of the granite, but is intrusively veined by it, and to be referred to an earlier period, we must conclude that the line of contact between these two rocks constitutes the true geological margin of the granite. Further, Messrs. Hall and Humphrey have pointed out[4] that the Moodies Series at Zwartkop is older than the granite, and have laid stress upon the gradual passage of the latter into a less acid marginal facies, as one approaches the Zwartkop ridge from the east. My own observations not only fully confirm those of Mr. Hall, but indicate the continuation of the granite margin from Zwartkop for some distance to the south-east, and the persistence of the marginal facies to within a short distance of Johannesburg.

It will be as well, however, first of all to notice briefly some of the more normal types of the granite, before describing the marginal modifications.

In its more central portion the granite does not show any great degree of variation, but is often very uniform in character over large areas. The rock exposed at the old Half-way House, on the Pretoria road, may be taken as a good example of the most characteristic and widespread type. This is a somewhat coarse rock of a pale pinkish-grey colour, with occasional large flesh-coloured felspars showing more conspicuously among the other constituents. Under the microscope it is seen to consist mainly of a somewhat coarse aggregate of microcline, plagioclase and quartz, with a few small flakes of white mica. The proportion of ferro-magnesian constituent is small, and consists of biotite, partially chloritised, and a very small quantity of green hornblende. Apatite is accessory, and a few small grains of epidote appear as a secondary constituent.

There are several varieties of this type. A local but by no means common variation shows a relatively high proportion of muscovite and microcline, observed on the farm Brakfontein No. 104, in the area further

---

[3] Hatch and Corstorphine, "Geology of South Africa," p. 95.

[4] Hall and Humphrey, "The Black Reef Series and Underlying Formations in the Neighbourhood of Kromdraai and Zwartkop," *Trans. Geol. Soc. S.A.*, vol. ix., pp. 14 and 15; also Annual Report Geol. Survey Transvaal for 1905, p. 72.

Digitized by Google

north. The more usual variations, however, are characterised by an increase in the proportion of the ferro-magnesian constituents, resulting in the formation of biotite-granites, hornblende-granites, and quartz-diorites. The development of biotite rather than hornblende seems to characterise the varieties nearer the more central portion, as, for instance, in the northern portion of Wilgespruit No. 80, and on Witkoppen No. 141, the rock quarried on the latter farm consisting of plagioclase, quartz, and biotite, while microcline is subordinate, and at the same time sphene makes its appearance. A variety showing a still further tendency in this direction is seen on the northern portion of the farm Nietgedacht No. 91, where a coarse, pinkish granite of the Half-way House type is intimately interbanded with a fine-grained dark variety, rich in biotite. The banded mass shows an irregular but well marked fluxion structure, and is evidently the result of an intermingling of two distinct modifications of the magma, owing to pressure acting previous to complete consolidation. The fine-grained dark variety is slightly more basic than the Witkoppen rock, and consists essentially of plagioclase, biotite, quartz, and sphene. It is allied to the tonalites.

The development of hornblende, rather than biotite, however, is perhaps on the whole a commoner feature, but is especially characteristic of the south-western border of the granite area between Mulder's Drift and the north-western suburbs of Johannesburg. Thus, as we approach the boundary of the granite in this part of the area, the normal type passes gradually into quartz-diorite and diorite, which are well exposed from the north-western portion of Wilgespruit No. 80, along the margin of the basic schists as far as the base of the Lower Witwatersrand escarpment north of Auckland Park and Sans Souci.

The majority of the rocks in this marginal portion of the granite may be described as more or less foliated quartz-diorites, the foliation being often very slight and scarcely noticeable under the microscope. They consist of plagioclase, quartz, and green hornblende, with usually some biotite, sphene, and secondary epidote. A highly foliated variety of the dioritic modification is exposed quite close to the base of the Rand quartzites in the south-east portion of Weltevreden No. 78, about two miles N.N.E. of Florida station. This rock shows very strong foliation under the microscope, in connection with which the quartz has been converted into a fine granular mosaic, the felspars have been broken and crushed, and the hornblende has been converted into flakey lenticular aggregates. Here and there rather conspicuous grains of secondary epidote tend to form "augen," round which the other constituents have been made to flow. The rock is a crushed quartz-diorite.

Modifications of a similar dioritic type, but in part of a finer-grained and more gneissic character, were observed by Mr. A. L. Hall along the granite margin on Zwartkop. Between this locality, however, and the farm Wilgespruit No. 80, to the south, this dioritic tendency is not maintained, though marked foliation is still invariably present in the granite, along its contact with the older basic schists, quartz-felsites, and sediments of the Moodies Series, and is occasionally accompanied by a passage of the coarse holocrystalline granite into a kind of quartz-porphyry. That is to say, that here the marginal modification is of a

Digitized by Google

distinctly acid character, and without any basic tendency, while foliation is still characteristic.

Thus the tongues of granite, which occasionally traverse the quartz-felsite at Mulder's Drift, are highly foliated and crushed, and the greater portion of them is seen to have been converted by cataclastic action into a fine-grained mosaic of quartz, felspar, and white (sericitic) mica, only the larger grains of quartz and certain portions of the felspar (microcline) remaining intact, and tending to form "augen."

Again, three miles west of Mulder's Drift, the most easterly of the two patches of Moodies Series is seen to be separated on its north-west side from the surrounding basic schists by a band of granite, which is apparently intrusive. This latter is a medium-grained muscovite-granite, and shows signs of partial crushing. Along its margin it becomes fine-grained and foliated, and consists of fairly numerous grains of quartz and a few small flakes of white mica in an exceedingly fine-grained and schistose matrix, almost felsitic in character, and consisting mainly of quartz, felspar, and white (sericitic) mica. The quartz grains are fractured and show signs of considerable strain. The rock may be described as a partially crushed quartz-porphyry, and represents a marginal modification of the granite at its contact with older rocks.

Foliated and crushed granite of the acid type is also found well developed along certain lines, which traverse the more central as well as the more marginal portion of the mass, and which have been indicated upon the map as lines of crush. These lines have a general north and south trend, and form conspicuous ridge-like features, often continuous in a direct line for considerable distances. They consist mainly of reefs of massive vein-quartz, which forms their central portion, and this is usually flanked on either side by a narrow zone of crushed and highly sheared vein-quartz and granite, both kinds of rock being often brecciated and crushed together. The central portions have also frequently been fractured and brecciated, the fragments having been re-cemented by a secondary deposition of siliceous material. The best example of these crush lines forms a well-marked feature, extending from the farm Witpoort No. 551 in a general S.S.W. direction to Klipfontein No. 479, a distance of twelve miles, and it is apparently coincident with the line of fault, which affects the Lower Witwatersrand Series on Waterval No. 79, to the north of New Clare. Another, but much smaller example of these crush lines, forms the prominent ridge behind Craighall Hotel. This has been recently described in a contribution to this Society by Mr. P. Wagner. These phenomena evidently point to the fact that large quartz reefs traversed the granite before it had been affected to any considerable extent by dynamic movements. Subsequently to the formation of these reefs, movements of lateral pressure caused brecciation of the reefs with differential movements along them, resulting in the crushing and shearing of the flanking rocks.

We have now noted the marginal modifications of the granite from Zwartkop to within a short distance north-west of Johannesburg. As we follow the granite further east, the dioritic phase is apparently no longer exposed at the surface, but an interesting modification is found along the

Digitized by Google

slopes of the north face of the Rand between Orange Grove and Bedford. This is the only locality along the Rand, so far as I am aware, where an actual contact can be seen between the granite and the base of the Lower Witwatersrand Series. In one or two other localities further west the granite, or rather its dioritic modification, can be seen within a few yards of the basement quartzites, but in the section between Orange Grove and Bedford we have a clear and well defined contact exposed for a distance of about a quarter of a mile.

This contact is, perhaps, best seen a short distance west of the western boundary fence of Bedford Farm, and one and a half miles east of Orange Grove. The normal coarse acid type of the granite crops out on the lower slopes of the escarpment, but within two or three yards of the contact it gradually assumes a foliated structure, which becomes more and more marked up to the actual contact, where the uppermost few inches of the granite are usually in a highly schistose condition. The line of junction is remarkably sharp, and the base of the quartzite presents a well defined and smooth under surface resting at an angle of about 35 degrees upon the granite. There is not the slightest indication of any intrusive behaviour on the part of the granite, such as characterises its relation to the basic schists and the older sediments of the Moodies Series. There are no signs of any intrusive veins or pegmatites in the quartzite, or of the granite breaking across from one horizon to another. The whole appearance of the section is that of a younger series of sediments resting upon an older mass of granite. Moreover, the lowest few inches of the quartzite frequently contain small rounded pebbles, sometimes almost in sufficient quantity to constitute a "banket," and occasional pebbles are also sometimes found at slightly higher horizons. The pebbles are of vein-quartz and quartzite; granitic fragments could not be detected with certainty. Apart from the presence of these pebbles, the basal portion of the quartzite is usually fine-grained and uniform in texture, though along a certain portion of the section it was seen to become coarse and gritty. These features recall those so often found at the base of the Black Reef quartzites, where they rest upon similar granite, and tend to the conclusion that the base of the Witwatersrand quartzite here constitutes a true basement bed, which has been deposited upon the granite.

On the other hand, the intensely foliated character of the granite along the junction strongly recalls the foliated marginal facies already described as intrusive as regards the basic schists and metamorphosed sediments of the Moodies Series; and moreover, its appearance under the microscope further tends to strengthen this resemblance. In a hand specimen the rock resembles a coarse acid granite that has been crushed and sheared, but under the microscope its character is rather that of a crushed quartz-porphyry or quartz-felsite, consisting of relatively large blebs of quartz, surrounded by a uniform matrix closely approximating the felsitic type, and in which individual minerals cannot be recognised, with the exception, perhaps, of minute, brightly polarising specks and flakes, probably representing sericitic mica. The quartz blebs are usually in the condition of granular aggregates, and show signs of considerable strain, being partially crushed and constituting phacoids, about which

Digitized by Google

the matrix has been made to flow by the intense pressure, which has evidently affected the rock.

The planes of foliation in the granite appear to strike usually in a direction parallel to the strike of the overlying quartzites, though in one place they trend in a more south-westerly direction, obliquely across the slope of the hill. The dip of the foliation was seen to be at a slightly higher angle than that of the overlying sedimentary strata.

The porphyry-like facies of the granite along the line of contact is certainly suggestive of intrusive behaviour, but one cannot accept this fact alone as good evidence of intrusion, without more definite and confirmatory indications in the field; whereas, as already pointed out, the field evidence leads distinctly to the conclusion that the quartzites were deposited upon the granite. Further, the large quartz grains in the coarse grit, sometimes found at the base of the quartzite, are seen under the microscope to consist of aggregates of quartz showing strain shadows, and resembling the quartz blebs seen in the foliated granite beneath, a fact which strongly suggests their source of supply, and further favours the conclusion of the later age of the quartzites.

This conclusion agrees with that of Dr. Corstorphine with regard to the relations between the Older Granite and the Lower Witwatersrand quartzites near Heidelberg[5] and with the opinions of other observers on the same question.[6]

In the Heidelberg section the occurrence of any schistosity or foliation in the granite at the contact is not mentioned by Dr. Corstorphine, but in every other respect this section appears to show identical features to that near Orange Grove.

The examination of the granite margin north of Johannesburg also to a great extent confirms Dr. Corstorphine's view that many of the schists formerly supposed to form part of the lowest portion of the Witwatersrand Series are in reality modifications of older igneous rocks. Thus we have the schistose granite near Orange Grove, and the fine-grained talcose and hornblendic schists, upon which the lowest sediments rest along the West Rand, and which are merely modifications of the basic igneous series already described.

The only example observed of a schist which, on the other hand, does appear to be conformable, and probably to form part of the lowest portion of the Witwatersrand Series, is a fine-grained red sericitic schist, exposed immediately beneath the lowest quartzite in the small gap or poort in the escarpment just below the Sans Souci Hotel. The coarse dioritic facies of the granite is exposed a short distance from it to the north. This rock cannot, in my opinion, be classed with the basic schists further west, nor can it be considered as representing a schistose modification of any variety of the granite. It is probably of the same character as the

---

[5] "The Geological Relation of the Old Granite to the Witwatersrand Series," *Trans. Geol. Soc. S.A.*, vol. vii., p. 9.

[6] D. Dörffel, "Note on the Geological Position of the Basement Granite," *Trans. Geol. Soc. S.A.*, vol. v., p. 104; and C. B. Horwood's contribution to discussion on above, vol. vi., p. 114.

Digitized by Google

sericitic schists described by Molengraaff from the lowest portion of the Witwatersrand Series in the Klerksdorp district.[7]

We may now briefly review the succession of geological events which took place in this district, according to the conclusions derived from the field evidence.

The earliest sedimentary rocks, of which we have any knowledge, are the Moodies Series, the surviving remnants of which are now seen on Zwartkop and Honingklip. After the formation of this series igneous activity broke out in the form of intrusive sheets of basic and ultra-basic material, and dykes of quartz-felsite. This was soon followed by a general invasion of the whole area by a vast acid magma, which consolidated as granite, with local dioritic modifications along its margin, due to the magmatic segregation of the more basic minerals towards the cooler portions. Huge veins or reefs of quartz were formed in fissures, probably produced during cooling.

Immediately following this invasion, and probably to a great extent connected with it, earth movements took place in the form of lateral pressure, resulting in differential movements, which caused tilting, dislocation, shearing, and crushing in the older sedimentary and igneous rocks and in the marginal portions of the granite, these movements being also especially felt along the edges of the quartz reefs, against which the granite was crushed.

Accompanying and succeeding these movements there was probably gradual elevation and denudation of the area, until much of the granite was laid bare. Then followed a period of depression, during which the Witwatersrand Series was deposited upon a gradually subsiding floor of granite and older rocks. At a later stage there were further movements, which perhaps accompanied the re-elevation of the area, and consisted apparently in lateral pressure from a general southerly direction. To this period we may perhaps assign the formation of the oblique strike-faults and other dislocations in the Witwatersrand Series; while it is not unreasonable to suppose that, at this stage also, there was a certain amount of differential movement between the basal portion of the Witwatersrand Series and the upper portion of the granite beneath, amounting possibly to a certain degree of over-thrusting, which caused the shearing of the granite along the line of contact, as seen near Orange Grove, and the production of sericite-schists from quartzose shaly rocks, occurring locally beneath the basement quartzites.

These movements were completed before the deposition of the succeeding Ventersdorp System, since a large portion of the Bezuidenhout Valley fault, which is included among the oblique strike-faults above referred to, is concealed by the unconformably overlying Ventersdorp rocks.

In concluding this account of the granite and its relationships, a brief reference may be made to the fault indicated upon the map as crossing the farm Waterval No. 78, north of New Clare, with a general N.N.E. and S.S.W. trend. To this is due the prominent outstanding portion of the main Witwatersrand escarpment, so conspicuous in any general view of

[7] Molengraaff, "Note on the Geology of Portion of the Klerksdorp District," *Trans. Geol. Soc. S.A.*, vol. viii., p. 16.

Digitized by Google

the Rand west of Johannesburg. This feature consists of massive quartzites of the Orange Grove Series, forming a well marked krantz, facing slightly west of north, the beds dipping fairly steeply to slightly east of south. The continuity of the lower quartzites with those of the main escarpment on the west is broken by one or two small faults, while on the east side of the projecting ridge the strata are seen to be sharply and obliquely cut off against the older serpentine and basic schist, towards which they dip on this side, and all the phenomena indicate the presence of a fault of the Bezuidenhout Valley type. Thus, in a section taken in the direction of dip across the ridge, and as far as the main Rand escarpment, we should traverse both the older igneous rocks and the Orange Grove Series twice over. Moreover, this fault appears to coincide with one of the main lines of crush in the granite, and so has apparently taken advantage of an older line of weakness.

The continuation of this fault further south or south-west was not followed up, but certainly requires further investigation, with a view to ascertaining whether there is any connection between it and any of the known dislocations in the Upper Witwatersrand Series on the West Rand, such, for instance, as that known as the Witpoortje break.

Digitized by Google

The Alteration of the Felspars in the Felspathic Quartzite underlying the Hospital Hill Slates (Read 24th June, 1907).

By R. B. Young.

[Plate VII.]

This quartzite is generally known as the "Speckled Bed," a name first given to it by Mr. D. Draper, on account of the numerous yellow and brown spots, due to alteration of the felspars, which it generally shows at the outcrop. These spots, however, are sometimes few or entirely absent. This is owing to the grey felspar in the rock remaining at places, as at Auckland Park, comparatively fresh, or to the manner in which the felspars have been replaced, as described below. Sometimes the felspars are reddish in tint, through the infiltration of ferric oxide along some of the cleavage cracks. The brown or yellow colour of the altered felspars is due to the presence of similar oxides.

The principal petrological interest of the rock lies in the course which the alteration of the felspar grains has taken. This mineral is most commonly microcline or orthoclase, though a little plagioclase also occurs. In the comparatively fresh rock at Auckland Park a certain amount of kaolinisation of the felspars has always taken place. In addition to this, secondary quartz formed in optical continuity with the original quartz grains adjacent to the felspar, replaces the latter pretty uniformly along the borders of the grains. Very frequently veinlets of quartz spread along cracks in the felspar. These widen, ramify and unite, until the remnants of the felspar grains are all enclosed within a network of quartz. Sometimes a more advanced stage of alteration is met with in which the original felspar grains are represented by grains of secondary quartz, in which there lie embedded a few scattered fragments of felspar retaining their original optical orientation. It may be that these are in connection outside the plane of the section examined.

Digitized by Google

The original boundaries of the felspar grains can frequently be ascertained through the production, during replacement, of flakes of sericite, especially along the borders and cleavage planes.

In some specimens taken from the neighbourhood of the Braamfontein Show Grounds, the alteration of the felspars is complete, but has taken different courses. Very many of the pseudomorphs are composed wholly of quartz and a light green muscovitic mica, probably sericite, and similar to that just mentioned as occurring in the Auckland Park rock. Others are of sericite mingled with cryptocrystalline matter, and are identical with pseudomorphs occasionally found in the comparatively fresh rock. Most of the porous clayey pseudomorphs so conspicuous in hand specimens have generally been destroyed during the manufacture of the microscopic section.

The pseudomorphs of quartz and sericite, which may be regarded as the normal products of alteration, are interesting. The original boundaries of the felspar grains are marked by lines of minute sericite flakes, which most often are more or less tangential in position. The bulk of the sericite, however, is massed within the grains, lying in patches, and in intersecting systems of planes, which obviously coincide with the original cleavage cracks of the felspar. The quartz of the pseudomorphs is partly in optical continuity with the surrounding grains, but in the interior it frequently appears as a mosaic, the individuals of which, however, may be continuous, with quartz grains lying outside the plane of the section. A considerable proportion of this secondary quartz occurs without any admixture of sericite (Figs. I. & II.).

As the distribution of the sericite, as described above, coincides with the probable areas of maximum kaolinisation in the felspar grains before replacement, it would not be unreasonable to suppose that the presence of abundant kaolin has determined the formation of the sericite. Dr. Sterry Hunt,[1] in his account of the crenitic hypothesis, points out that the production of muscovitic micas by the union of soluble silicates with the kaolin of decayed felspars is theoretically possible, and I am inclined to believe that this has taken place in the case now being considered.

A sufficient explanation of the variation observed in the alteration of different felspar grains is to be found in their varying chemical composition and crystalline structure.

Messrs. Hatch and Corstorphine,[2] in the course of a very brief description of the "Speckled Bed," suggest that it was originally an arkose with comparatively little felspar. They do not, however, recognise the fact, which is evident from the foregoing, that the clayey pseudomorphs of felspar may, as in the specimens I have examined, represent only a small proportion of the total felspar originally present in the rock. The rock must at first have been much more felspathic than a macroscopic or casual microscopic examination of some portions of it would lead one to believe.

---

[1] "Mineral Physiology and Physiography," New York, 1891, p. 161; see also Van Hise, "A Treatise on Metamorphism," Monograph, U.S. Geol. Survey, 1904, pp. 254-257.

[2] "The Geology of South Africa," London, 1905, p. 111.

Digitized by Google

DESCRIPTION OF MICROPHOTOGRAPHS.

Fig. 1.—The non-felspathic variety of the "Speckled Bed" from Braamfontein, in which the original felspar grains are mostly replaced by quartz and sericite, the latter of which appears lit up, thus revealing the former outlines of the felspar grains, and in some cases the traces of their cleavage planes. Diam. × 16. Nicols crossed.

Fig. 2.—A small portion in the middle, to the right, of *Fig.* 1, showing a grain of felspar replaced entirely by quartz and small flakes of sericite, which lie along the original border of the felspar grain, and also along some of the cleavage cracks. Diam. × 87. Nicols crossed.

Digitized by Google

The Occurrence in Kimberlite of Garnet-Pyroxene Nodules carrying Diamonds (Read 24th June, 1907).

By Geo. S. Corstorphine.

In the two years during which the Roberts Victor Mine, on the farm Damplaats, Boshof, Orange River Colony, has now been opened, many so-called "eclogite boulders" have been found in the yellow ground. They are composed chiefly of garnet and an emerald green pyroxene, with which, in many cases, kyanite is associated. The minerals are arranged either in true granitic structure (*körnige Structur*), or occasionally they are in layers as in a typical granulite. The nodules which I have seen are either spheroidal or ellipsoidal in shape, many, however, being incomplete, having obviously been broken across.

On a recent visit to the mine I was shown by Mr. J. L. van Eyssen, the Manager, such a nodule which had, on careful examination, been noticed to have on the outside no fewer than eight diamonds, some of them quite minute splints, but one or two well shaped octahedra of approximately one-fifth to one-sixth of a carat. The piece of rock as originally found was a broken portion about 3 inches by 5 inches by 1¾ inches of a flattened ellipsoid. On the outside of the nodule the pyroxene appears of a light yellowish-green colour, in some places almost white, and quite amorphous, having weathered into a soft powdery material in which the dark red garnets appear set like currants in a cake. The garnets are generally more or less rounded. Though in the majority of cases they occur as separate individuals, they show little evidence of dodecahedral or other crystal outline. Their outer surface has a curious appearance, as if the individual crystals had been flattened or hammered out while in a plastic condition.

On a clean-cut surface of the inside of the rock one can see, even with the unaided eye, that the garnets all have a weathered "kelyphite rim," while the pyroxene on certain planes shows a distinct *schiller*.

Digitized by Google

Fig. 1 is a photograph of a cut surface showing, near the upper edge, one very small diamond and the broken half of another of approximately one third of a carat. These two diamonds were found as this piece of the rock was being cut to obtain a fresh inner portion for a section. Two other small diamonds were similarly discovered on another section, a third on cutting a thin slice, and three were obtained by breaking pieces off the original nodule, so it may be assumed that there are several other diamonds embedded in the various fragments into which the nodule has been broken, in addition to the sixteen accounted for.

FIG. 1. Portion of the garnet-pyroxene nodule from the Roberts Victor Mine, showing two diamonds. (Natural size.)

In the above figure the rounded outline of the cut garnets can be seen, the intervening lighter portions being the pyroxene.

In a thin slice of the rock under the microscope the "kelyphite rim" of the individual garnets is seen to consist as usual of biotite and a serpentinous material, which also passes through the crystals in innumerable cracks. The pyroxene shows much alteration material, greyish in colour, occasionally in fibrous form, as in the typical alteration of salite in salite diabase. This pyroxene is chrome-diopside, and the garnet pyrope.

The whole of each of the four sections of the rock which I had made, consists of the above two minerals and their alteration products, and the rock agrees closely therefore with the first specimen described by Professor Bonney from the Newlands Mine.[1]

The question of most interest is the origin of such rocks in the diamond bearing breccias. There are three possible explanations of their presence: first, as Professor Bonney wrote,[2] they may be boulders of eclogite which, after having been rounded by water action, formed for a time a constituent part of some conglomerate (Bonney mentioned the Dwyka as probable), from which they were brought up by the volcanic activity of the pipe; second, they may be pieces of a basic igneous rock altered into eclogite by metamorphism in the pipe, or, third, they may be concretionary nodules formed in the original matrix of the material which we call blue ground or kimberlite.

Professor Bonney's explanation above quoted appears to me far from satisfactory, involving, as he himself pointed out, the question of an

[1] T. G. Bonney, "The Parent Rock of the Diamond in South Africa," *Proc. R. Soc.*, vol. lxv., 1899, pp. 223-236.

[2] *Ibid.*, p. 235.

Digitized by Google

eclogite being the "parent rock of the diamond in South Africa." Bonney held that not only the diamond but the diopside and the garnet of the pipe breccias originated from an eclogite or related rock.

Although a purely negative argument against this explanation, the fact cannot be ignored that in no part of South Africa has an eclogite mass been observed, nor have eclogite boulders been found in the Dwyka Conglomerate. Such a conspicuous rock, either occurring *in situ* or as boulders, is not likely to have been overlooked in a country where so much prospecting is carried on. Further, as to eclogite being the parent rock of the diamond, it is strange, if this be so, that no eclogites elsewhere have been found to contain diamonds.

As regards the second explanation above given, it is sometimes assumed that eclogites occurring among the crystalline schists are products of metamorphism. This, however, is not a likely explanation of the presence of the "boulders" in the diamond pipes. The foreign rocks which are found in blue ground are conspicuously normal: in fact, I have never seen any fragments showing a trace of igneous alteration. The alteration of both minerals and rocks in the blue or yellow ground has been caused by the main agent of ordinary atmospheric weathering—percolating water with the usual gases and acids in solution. In the blue ground one finds boulders and fragments of sandstone, shale, different types of granite, as well as diabase and related rocks, all without any sign of contact metamorphism. It would be strange, therefore, if fragments of some type of igneous rock had been subjected, in a diamond pipe, to such thoroughgoing metamorphism as would be indicated by the production of an eclogite.

It seems to me that the so-called "eclogite boulders" are really concretionary nodules formed by segregation or differentiation in the original magma, and comparable therefore with the basic patches so common in granite, and with the olivine nodules in some basalts. This explanation, I find, was also offered by Professor Beck,[3] of Freiberg, in his description of a series of specimens from the Newlands Mine including a part of the same "boulder" as was described by Professor Bonney.

For this view I had unwitting support, during a visit to Jagersfontein, from one of the oldest miners there, who told me that such nodules were very abundant in the yellow ground, but that they were not found in the blue ground. The fact, of course, is that the nodules, like concretions generally, are much more resistant than the normal portions of the yellow ground, and remain as hard lumps, easily detected when the soft and decomposed upper part of the pipe breccias is worked, whereas in the blue ground there is a closer approximation in the hardness and resistance of the unweathered matrix to the physical condition of the nodules.

The generally rounded character of the nodules and the peculiar appearance of the outside of the garnets is typical of such segregations, and is not due to water action. In fact, none of the numerous nodules which I have examined show rounding similar to that produced by moving

[3] R. Beck, "Neues von den Afrikanischen Diamantlagerstätten," *Zeit. für prakt. Geologie*, 1899, pp. 417-419.

Digitized by Google

water, but appear to have been corroded. In some cases the garnets have been more attacked than the pyroxenes, which stand out on the surface just as the garnets do in other instances. The nodules are more compact and impermeable than ordinary kimberlite, and no doubt percolating water tends to surround them and attack the outer layers of minerals.

There is no question, however, that many of the nodules, as is the case with the diamond-bearing one from the Roberts Victor Mine described above, have been broken in the course of movement in the pipe. The broken surface of that nodule has quite a different appearance from the original ellipsoidal exterior. The garnets are distinctly jagged, and the entire surface shows a true fracture unworn and unsmoothed. This may be taken as evidence that the rounded outline of the nodule is not due to attrition in the pipe. It may have travelled a considerable distance from the centre in which it solidified, but it certainly has not been worn or rubbed since it was broken.

Professor Bonney, in his second paper[4] on the Newlands "boulders," gives, in his own description of them, evidence which to my mind favours the concretionary origin. In his second suite of specimens he found just that amount of variation in mineralogical composition which is to be expected in concretionary nodules in igneous rocks, and which accounts for the various names he had to apply to his hand specimens.

On the view that these boulders are concretions in the original kimberlite magma, the presence of diamonds in them supports the theory that the diamond originated in the blue ground, and has not been carried in from some foreign source. After Professor Bonney's explanation that the "boulders" represented the original source of the diamond, Mr. Gardner Williams[5] had twenty tons of similar nodules from the Kimberley mines separately crushed and washed without a single diamond being found. This result is rather incomprehensible on the theory that the diamonds, garnets, and diopside of the blue ground were derived from some underlying eclogite, of which the so-called boulders are the largest pieces remaining intact. On the other hand, if the "eclogites" are concretionary nodules formed in the original kimberlite magma, the sparse occurrence of diamonds in them is not peculiar. Of the nodules which have been found and examined, the two from the Newlands Mine, described by Professor Bonney and by Professor Beck, and this third one from the Roberts Victor Mine, have been proved to contain diamonds.

In such nodules graphite is also occasionally found. Some time ago Mr. David Draper gave me a coarsely crystalline garnet-pyroxene nodule from Jagersfontein, which shows between the pyroxenes occasional patches of flaky graphite, the carbon of which we may reasonably assume would, but for the absence of some unknown factor, have appeared as the diamond.

---

[4] T. G. Bonney, "Additional Notes on Boulders and other Rock Specimens from the Newlands Diamond Mines," *Proc. Roy. Soc.*, vol. lxvii., 1901, pp. 475-484.

[5] Gardner F. Williams, "The Diamond Mines of Kimberley," *Science in South Africa*, Capetown, 1905.

Digitized by Google

Publications of the Geological Society of South Africa.

The under-mentioned publications can be purchased at the Office of the Society at the following prices :—

Annual Transactions	...	...	...	£2	0	0
Quarterly Parts ...	...	...	...	0	15	0
Half-Yearly Parts (of certain volumes)			...	1	1	0
Monthly Parts (of certain old volumes)			...	0	2	6

There is a reduction of fifty per cent. on the above prices to Members.

OUT OF PRINT—Vols. I. and V. ;
Vol. II. ; Parts 1, 2 and 11.

Anyone possessing these volumes and parts of volumes that are out of print, and wishing to dispose of them, should communicate with the Assistant Secretary.

The Transactions may be obtained from Messrs. Wm. Wesley & Son, 28, Essex Street, Strand, London, W.C., who are the Society's European Agents.

Digitized by Google

LIST OF OFFICERS

OF THE

GEOLOGICAL SOCIETY OF SOUTH AFRICA

For the Year 1907.

President:

E. JORISSEN.

Vice-Presidents:

GEO. S. CORSTORPHINE. J. McCLELLAND HENDERSON.
H. KYNASTON.

Honorary Secretary and Treasurer:

J. H. RONALDSON.

Council:

WM. ANDERSON.
C. B. BRODIGAN.
J. T. CARRICK.
GEO. S. CORSTORPHINE.
†A. VON DESSAUER.
H. S. HARGER.
J. McC. HENDERSON.
W. G. HOLFORD.
G. G. HOLMES.
C. BARING HORWOOD.
W. A. HUMPHREY.
†H. LUTTMAN-JOHNSON.
†J. P. JOHNSON.
E. JORISSEN.
†C. B. KINGSTON.
H. KYNASTON.
*J. G. LAWN.
E. T. MELLOR.
E. H. V. MELVILL.
†F. P. MENNELL.
†A. W. ROGERS.
J. H. RONALDSON.
A. R. SAWYER.
F. W. VOIT.
*D. WILKINSON.
R. B. YOUNG.

*Resigned during the year. †Elected during the year

Assistant Secretary:

W. W. R. JAGO,

Office: 18, National Bank Buildings, Simmonds Street, Johannesburg.
Postal Address: P.O. Box 1071, Johannesburg.

Digitized by Google

Kimberlite Dykes and Pipes (Read 22nd July, 1907).

By F. W. Voit.

The restless prospecting for diamonds has lately increased more and more, and the opening up of fissures and pipes throws a new light on the geology of the much sought for diamondiferous kimberlite rock, and on the origin of the gem itself.

It is now an established fact among South African geologists that all pipes are connected with fissure veins, as the popular expression runs, or in other words that we find the pipes along lines of fissure.

From a geological point of view the so-called fissure veins are nothing but true dykes which, in their strike, follow the general lines of weakness or the tectonic tendency of the country. In most cases they do not run singly, but several of them can be followed, parallel to each other, for miles. They are sometimes continuous, sometimes they are inclined to pinch out; and in this lenticular character in strike as well as dip they resemble true dykes.

Petrographically the kimberlite dyke-rock is an aggregate of even-sized grains of serpentine with sometimes abundant small flakes of mica; the well known accessory minerals are very rare and of rather small size. Few foreign fragments occur in the rock, which, in its homogeneous and uniform character, resembles a volcanic rock, and there seems to be little or no doubt that pre-existing cracks and fissures were filled by a slowly extruding magma.

The pipes are found on the lines of the kimberlite dykes. Their geological occurrence, their shape, and their petrographical character, however, are so entirely different from the dykes, that I cannot understand how the idea prevailed for so long that pipes and dykes were contemporaneous, and that the pipes were nothing but widenings of the fissures.

First of all there can be no doubt that the pipes are younger than the fissures; we know that in nearly all instances the fissures stop at the pipe, which practically means, that the pipe is younger, and having been extruded on the line of fissure, has cut off the dyke at that point.

Digitized by Google

Very often the dyke-rock and that of the pipe are entirely different, and the occurrence of inclusions of undoubted dyke-rock in the pipe is very common; excellent examples of large dyke fragments could, for instance, be observed in the pipe of the Regina Mine.

Furthermore our experience shows us that the pipes, though sometimes taking irregular and eccentric forms near the surface, are generally elliptical or rounded, and at a depth resemble circular vents. The walls of these vents are generally very clearly defined, and not corroded, which would be the case if the extruding magma had eaten its way, say, at the intersection of two faults or dykes. The more or less circular shape of the vent gives one the impression that the magma had been blown through the formation with great force, as in this way only could these clean circular holes have been drilled.

Petrographically the pipe-rock is much more variable in character than the dyke-rock. Generally it is an aggregate of fragments of serpentine, which microscopical examination shows to be probably an altered olivine. The abundant small-sized micas, typical of dyke-rock, are conspicuous by their absence as constituent minerals. The well known accessory minerals, such as large flakes and bundles of mica, garnets, olivines, pyroxenes, diamonds, etc., are more frequent and of larger size. The numerous fragments of eclogites and the large numbers of foreign rock fragments, belonging to much older horizons than the country rock in which the pipes are found, are characteristic of the latter. Rounded and brecciated fragments of exotic rocks, such as gneisses, granites, and crystalline schists, may be taken as undoubted indication of a true pipe.

There is no doubt that in some cases pipe and dyke-rocks resemble each other; that a fissure-rock shows an exceptionally large amount of certain accessory minerals, and that it would be very difficult to say from a hand specimen whether it belongs to a pipe or a fissure. In all these cases, however, an examination of a greater number of specimens would settle the question.

I freely admit that the difference between dyke and pipe-rock may be due in a certain degree to the quicker cooling of the magma between the narrow walls of the fissure, as Dr. Sandberg is inclined to suggest. Never, however, has there been observed any gradual merging of dyke-rock, with its characteristic constituents of serpentine and mica, into pipe-rock without the small micas as a constituent part. On the contrary, the contrast between the two rocks is extraordinarily well marked in the immediate vicinity of the pipe.

We have nearly circular pipes more than 1,000 feet in diameter, into which a fissure only a few feet thick leads, without any widening towards the pipe. The entrance of the fissure into the pipe is abrupt. Pipe and dyke-walls at the junction make sharp angles, and there is no tendency of the dyke to gradually take on the rounded shape of the pipe.

Sometimes we may observe that the extruding pipe-rock extends into the fissure, as towards the direction of least resistance. This occurs, for instance, at the Monastery Mine. I think, however, that this, in most cases, happens very close to the original roof of the pipe, where the explosive force had gradually passed into a laterally directed expanding force.

Digitized by Google

Now it is admitted that dyke and pipe rock are chemically of the same or very similar composition, the two magmas being consanguineous.

The magma, then, must have been identical; the conditions, however, under which the two magmas extruded and solidified must have been different; little or no pressure when the dyke-rock solidified, great or excessive pressure when the magma in the pipe solidified. We cannot imagine that fragile minerals, such as mica, enstatite, etc., have come from great depths, as in this case they would have been crushed to atoms in the ascending magma. But apart from that, if these large aggregates of mica, garnet, etc., sometimes as large as a man's head, came from great depths—say, from the crystalline schists—where can we find such enormously thick beds of pure garnet and mica-rock? One would expect that these minerals, in at least a few cases, were connected with felspar or quartz. They have, no doubt, crystallised out *in situ*, just as the various other minerals did, but I think it a very far-fetched idea to suppose that the great masses of eclogite which are found in the pipes should have come from those depths where granitic, gneissic, etc., fragments were torn off by an extruding magma. In this case one would expect that the eclogites, micas, etc., taken as fragments of deep-seated rocks, would occur in at least a certain proportion to the granitic, gneissic, etc., fragments, but the masses of eclogite occur in overwhelming proportion to the fragments of exotic rocks.

Should we admit that those eclogite nodules are of deep seated origin, we must attribute the same origin to all the other nodules, especially to those egg-shaped and perfectly rounded nodules of iron pyrites we find so often in the mines. These iron pyrites nodules show exactly the same surface as the eclogites, which is generally very uneven and has a corroded appearance, but at times presents a smooth surface, similar to slickensides. Not the slightest trace of decomposition is seen on these pyrites nodules, and the idea that a mineral like pyrites, whose stability towards chemical agencies is so very low, should have come up with the ascending magma, is, of course, ridiculous. If, however, we find such an apparently corroded surface on the iron pyrites nodules, which is nothing but an incomplete form of crystallisation, we need not attribute the corroded character of the eclogite nodules to their movement in an ascending magma.

There is in my mind little or no doubt that the eclogites are nothing but concretions in a chemically very similar magma, and that they originated *in situ*, an idea I have already formulated in a paper sent to the *Zeitschrift für praktische Geologie* in February last.

I think we can compare the eclogite concretions to the olivine nodules which we find in serpentines and diabases, and to those olivine nodules, pyroxene-garnet aggregates of the Finkenberg, near Bonn, described by Zirkel as Urausscheidungen, *i.e.*, primarily formed aggregates which are differentiations of an originally heterogeneously mixed magma.

The large crystals of mica, pyroxene, and the eclogitic rocks, with their structure similar to plutonic rocks, suggest the idea that, during the solidification of the kimberlite magma, conditions must have been present under which a mineralising agent or crystallisator, such as steam, borides, fluorides, chlorides, carbon dioxides, etc., could influence the magma. The

Digitized by Google

efficacy of these crystallisators is greater when they are in an overheated state, and the latter one will, of course, only depend on the pressure the gases are under, and we come to the conclusion that the kimberlite magma must have been under great pressure when it began to cool down and solidify.

From the shape of the mines in depth, as mentioned above, we must admit that the extruding of the pipe magma must have taken place in a somewhat violent manner. On the other hand we notice at the upper portions of the mines very large masses of the so-called floating reef, which are included fragments of the surrounding shales, dolerite, etc. This floating reef covers, in many cases, the greater part of the pipe, the kimberlite cropping out only in places. At greater depths this floating reef disappears, and though fragments of the country rock still occur, the pipes show an inclination to become cleaner. As illustrations, the Kimberley West and the Lace Mines may be cited.

The fragments of floating reef at the surface of the mine are in most cases identical with the rocks which form the walls of the pipe, and we sometimes find the whole mine more or less covered by them. An excellent example of this was the Jagersfontein Mine, where an enormous mass of basalt, the country rock of the pipe, covered more than two-thirds of the surface of the mine as a flat cone, the axis of which was some 250 feet. Its presence disguised for a long time the true character and size of the pipe, and originated the idea that three different fissures had broken through the formation.

We have a further instructive example in the old Theron (now Kimberley West) Mine, the greater part of whose surface was covered by floating reef, but the mine became cleaner and cleaner in depth. There the floating reef is broken through by innumerable ascending fissures pinching out towards the surface, just as was the case with the large basaltic mass of the Jagersfontein Mine, and the impression is given that the ascending magma had not had force enough to break through the overlying formation.

We have a similar case in the Voorspoed Mine, where the amount of floating reef has obscured the true size of the pipe.

We know from Dr. Corstorphine's description of the Lion Hill Mine that the pipe is widening out under the surrounding shales. The yellow ground, which takes the form of a dome, crops out only to a small extent, an example which is repeated at the Loxtondals. All these facts, which could be strengthened by many other examples, together with the structural and textural qualities of the pipe rock, produce the impression that the magma had not been able to break through the overlying formation. When extruding, it stuck fast in the earth's crust and solidified in fractures, which took circular, elongated, elliptical, or eccentric forms, according to the amount of pressure forcing the magma from below into the overlying formation.

According to these remarks the pipes were formed as conical batholites. We have, so far, not yet found a true batholite, and of course such a discovery will be purely accidental. We have, however, very similar geological examples, though small ones, in true intrusive sheets, in the Roberts Victor, Vulcan, and Harrisdale Mines.

Digitized by Google

There is another peculiarity in the pipes which throws light upon the conditions under which they were formed.

We know that very often the rock in a mine has local differences. The western part of the Kimberley Mine, for instance, which goes down like a large conical stem, differs from the larger remaining part of the pipe very much, and is so poor in diamonds that it has not been touched till now. Similar occurrences have been reported from other mines where various columnar portions differ from each other in such characters as colour, composition, contained minerals, and richness in diamonds, and the idea suggests itself that the difference in mine ground is due to different extrusions of kimberlite.

Concluding my remarks I venture to put forward the following hypotheses of the genesis of the kimberlite dykes and pipes:—

By tectonic disturbances, cracks and fissures were formed on the lines of least resistance, along which the kimberlite magma found its way towards the surface. On its way it widened the fissures, corroding the walls, and occasionally breaking off fragments from them, and just as the fissures widen or pinch out, extend up to the surface or stop in the formation, the kimberlite magma intruded into the existing cavities, at times slightly lifting up the overlying formation.

Through the material drawn from the seat of the kimberlite magma in depth a change in its physical and chemical conditions took place. The melting point of the overheated magma was reached, and certain elements enclosed in the magma developed their chemical affinity, and formed gases of a highly expansive nature, which overcame the pressure upon the magma and forced their way towards the surface along those dykes where they found least resistance.

It is most probable that when the pressure upon the magma was overcome by the expansive forces this took place in a more cataclysmic way, and this sort of extruding is strengthened by the shape of the pipes in depth, where the vents resemble holes drilled in the earth's crust. It can be imagined that the explosive forces ceased in the same degree as they had to overcome resistance, and finally stopped when the gases escaped through cracks and faults, and the extruding force was counteracted by the weight of the overlying formation; it goes without saying that the eruptions were repeated on a smaller scale till the state of equilibrium was again reached.

The first extrusions formed, so to say, the pipes, and filled them with their mineral contents, while the latter extrusions were chiefly of a gaseous character. While the extruding magma began to cool down and solidify under high pressure from the overlying roof and the existing gases, minerals such as mica, garnets, and pyroxenes began to crystallise out, while the gaseous eruptions again influenced the still plastic magma. I think that hot vapours, especially steam, must have played an important rôle, not alone as a crystallisator, and, so to say, soaked thoroughly through the magma. The brecciated character of some minerals, such as mica, might be attributed to this later series of magmatic and gaseous eruptions.

With regard to the generally accepted term, kimberlite breccia, I

Digitized by Google

should like, however, to point out that we can only speak of a real breccia with regard to the angular, seldom rounded, fragments of foreign rocks. In this respect the kimberlite resembles the many volcanic breccias we find in South Africa. I can, however, not attribute throughout a brecciated character to the accessory minerals and eclogites, which are certainly, in most cases, of roundish shape, and form concretions in the magma. We need not necessarily take the broken nature of, say, micas as a result of friction when moving up and down in a magma, but as a result of the contraction of the cooling magma. We find, for instance, very many broken micas in the granite, and in pegmatite veins, where their crystallisation *in situ* is beyond doubt.

Concluding these remarks on the petrographical character of the kimberlite rock in the pipes, we may comprise all the characteristics in the following way: The pipe kimberlite is an intratelluric pneumatopyroclastic breccia of a serpentinised porphyritic peridotite which stands between a plutonic and a volcanic rock. The pipes are embryonic volcanoes, and what we see now is a section laid bare by the denudation of the original summits.

Digitized by Google

The Origin of Diamonds (Read 22nd July, 1907).

By F. W. Voit.

When formulating any hypothesis on the origin of the diamond we have to consider two points:

(1.) The mode of occurrence of the diamond.

(2.) The manner in which it can be produced artificially.

So far we may take it for granted that kimberlite is the only rock in which the diamond occurs as a primary mineral. There are certain rumours that in India and Lapland the diamond occurs as an original constituent in pegmatitic veins penetrating granite, and that in Australia they occur in dolerite. We have no reliable data as to these occurrences, and there is no doubt that the diamond in other parts of the world is in all cases found in secondary deposits, such as sandstones, gravels and sands.

This paper deals only with the origin of the diamond in the pipes, and I do not, therefore, touch on the question of the origin of diamonds which are found in rocks of older horizons, such as itacolumite in Brazil and in the Witwatersrand Beds near Klerksdorp, in the Transvaal.

With the exception of the occurrence in meteorites, which will be dealt with later on, kimberlite is the only rock in which the diamond has been found as a primary constituent.

Though it is admitted that the origin of the diamond in the pipes is still doubtful, so far the theory is generally accepted that the diamond is formed at unknown depths and brought into the pipes by volcanic action. There are, however, very many strong points against this theory.

If we examine a parcel of diamonds, we observe that they are in most cases fine crystals, showing crystalline edges and angles. The edges and corners of the crystals and fragments are always perfectly sharp, and not even the faintest traces of rounding can be detected.

I cannot imagine that those perfect octahedra found by thousands in the Kimberley mines can have travelled many thousands of feet up a narrow channel, where they must have undergone a good deal of attrition

Digitized by Google

by the magma which brought them from unknown depths. The number of the so-called splinters we find in the mines is, relatively speaking, very low, and in most cases they will be portions of those diamonds which were not perfectly crystallised, which are full of cracks and fissures, in which the coherence is very loose. These may break very easily by the relief of pressure in mining, or during the washing process. Finally I do not see why a great number of these chips should not be regarded as imperfectly crystallised carbon in its densest form.

If all the diamonds came from certain depths where they have been formed, one would expect a greater uniformity in the stones of certain groups of mines. We know, however, that all the mines round Kimberley vary very much in the yield and in the stones themselves. Each mine has got its characteristic stones, and this peculiarity is so pronounced that experts in most cases can easily say where certain stones come from. These characteristics of the stones in the individual mines point to the fact that the mines themselves—*i.e.*, the physical and chemical conditions under which they were formed—are responsible for yield, shape and other peculiarities of the stones.

Suppose the diamonds have not been formed in the pipes themselves, but brought from a deep-seated source, one would expect to find more diamonds at a depth; an augmentation of the yield with depth ought to occur, while just the contrary seems to be the case.

The chief argument for the theory of the formation of diamonds in depth has always been the discovery of diamonds in garnets and eclogite boulders. So far, relatively speaking, only few specimens have been found, but I am sure that the occurrence of diamonds in garnets and eclogites, and even in all the other accessory minerals as pyroxenes, micas, etc., happens much oftener than we know, as a discovery like that is only an accidental one.

I have stated above that the accessory minerals, and with them the various eclogites which are not boulders at all, are extremely unlikely to have been derived from great depths, and I hardly believe that the idea can any longer be maintained that all the eclogites, saxonites, lherzolites, etc., could be derived from deep-seated formations so far unknown to us. I perfectly agree with Dr. Corstorphine that they are, no doubt, concretions in an absolutely consanguineous magma, formed *in situ*, and as the diamonds occur right in them, the diamonds must have been formed *in situ* also. The strongest point, however, against the theory that the diamond was brought up in the pipe by the ascending kimberlite, lies in the fact that only recently in Leipsic experiments have proved that diamonds can be dissolved in ordinary blue ground by heat and pressure. If this be the case, then all the diamonds formed in depth might have been dissolved in the ascending kimberlite magma.

If we agree that the diamond was formed *in situ* in the pipes, the question arises how it was formed there. Here the association of carbon with ferruginous matter and the artificial production of diamonds must be considered.

In meteors carbon has been found as small diamonds, associated with olivine and pyroxene, and as graphite in hexahedral crystals. This so-called cliftonite has been described as a paramorph of graphite after

Digitized by Google

diamonds, which would mean that the diamond has degenerated into graphite, though it is probably much nearer the truth that this graphite is only incompletely crystallised diamond.

We know, further, that an excess of carbon in molten iron, when cooling down, crystallises out as graphite, and the occurrence of graphite crystals in cast-iron and meteoric iron is a well-known fact.

Moissan demonstrated that if carbon was dissolved in molten iron, and the whole mass solidified under high pressure, carbon crystallised out as diamond, and J. Friedlander's more recent experiments prove that graphite, when dissolved in fused olivine, crystallises out again as diamond, though in this case in a much more diminutive form than in Moissan's experiments, which may be due to the absence of pressure.

The recent experiments with metallic carbides by Professor Dr. A. Frank, of Charlottenburg,[1] who succeeded in producing a modification of a very pure graphite of great hardness, are of the greatest importance. In a heat of 1,600° Centigrade he produced from lime and coal calcium-carbide and carbon monoxide, and by lowering the temperature he again got lime and the above-mentioned graphite.

Frank mentions that, in heating carbides with various other elements in gaseous form, such as chlorine, phosphorus, arsenic, etc., he always got, besides the metallic compound of the respective element, carbon in the shape of graphite, and he hints at the idea that by increasing pressure and temperature, the production of carbon in its densest crystalline modification, *i.e.*, diamond, out of metallic carbides might be possible.

All the ingredients required for the artificial production of diamond we find contained in the kimberlite rock.

As to the carbonaceous matter, the idea has been suggested that this may have been derived from the carbonaceous shales which are penetrated by the pipes. This is a very far fetched idea indeed, as we know that diamonds occur at depths where no carbonaceous formation is present, and the walls are formed of granite.

Besides that, we have found shale fragments in the pipes containing small seams of anthracite. In this case, then, the coal in the shales, by contact metamorphism, was simply altered into anthracite.

That carbon exists in some form or other in the interior of the earth we may take as granted, as we know that active volcanoes exhale great quantities of carbon-dioxide. Furthermore, graphite occurs in the very oldest rocks of Laurentian age, whose magmatic character is agreed upon even by the most stubborn Neptunists, and I venture to hint at the idea

---

[1] Prof. Dr. Adolf Frank of Charlottenburg, "Ueber die Gewinnung von Kohlenstoff—Russ und Graphit—aus Azetylen und Metallcarbiden," *Zeitschr. angew. Chem.*, xviii., h. 44, 1905.

Digitized by Google

that occasionally diamonds may have crystallised out in solidifying magmas of the earth's earliest periods; this, then, would explain the occurrence of diamonds as part of the detritus of those old magmatic rocks, in the old sedimentary formations mentioned above.

Carbon no doubt exists in the interior of the earth, and is associated with ascending magmas.

Indeed, we find carbonaceous matter plentiful in its graphitic form in the pipes, and I think it is of great interest that in the eclogite concretions of the Roberts Victor Mine graphite has been found together with the diamonds. It goes without saying that iron must have been an original constituent in the kimberlite magma.

While Friedlander's experiments show us that the formation of diamonds in an olivine magma is possible, and will be possible in such a similar magma as blue ground, Moissan's experiments show us that carbon and iron, under heat and great pressure, will produce diamonds.

Frank's experiments finally point to the probability of producing carbon in its densest crystalline form with the help of a mineralising agent or crystallisator, such as metallic carbides combined with pressure.

I am, of course, not going to say that a great pressure will be necessary for forming diamonds directly, or that we could produce diamonds by compressing carbonaceous matter; but indirectly pressure will have an influence as crystallisator, as the powerfulness of a mineralising agent is in direct relation with heat and pressure.

That the solidifying kimberlite magma was under great and even excessive pressure, can easily be imagined if we assume, as above described, that the kimberlite magma never reached the surface. We may very well imagine that after the pipe was formed and filled chiefly with its mineral contents, which sometimes were forced into ascending cracks and fissures of the overlying rocks, the magma began to solidify.

The first minerals crystallising out were, of course, diamonds, as these can stand the greatest heat, after which garnets, pyroxenes, micas, etc., were formed, as minerals whose stability towards heat is not so great.

Under normal circumstances a fully crystalline rock, similar to eclogite, might have resulted. A series of secondary extrusions, however, especially of a gaseous character, worked on the semi-plastic magma, when the temperature was lowered already to such a degree that in consequence of the increasing viscosity the magma was not influenced any more by the mineralising agents, which lost their mineral producing character.

With regard to the mode of occurrence of carbon in the magma, the idea has been suggested that either carbon dioxide or carbon in some liquid form may have been present. According to Moissan's, and especially Frank's experiments, I think that carbon in the form of metallic carbides

Digitized by Google

was a constituent part of the magma when it forced its way into the pipes. According to the pressure under which the kimberlite magma existed, diamonds crystallised out in a more or less perfect state, either in perfect crystals, sometimes coloured by iron, or in imperfect stones or aggregates of same, full of cracks or fissures, which were filled with graphitic matter or hydroxides of iron, or similar metallic contents. Finally, if physical and chemical conditions were not favourable, metallic compounds, or graphite, or carbon dioxides, etc., were formed.

The richness of the kimberlite will depend on the amount of metallic carbides present in the magma, and on the pressure under which it was during the cooling down, and we can easily imagine that the local conditions were such as to give origin to diamonds in fissures occasionally, or, on the other hand, not to produce any diamonds in the pipes at all.

The idea, therefore, that on a fissure vein, comparatively rich in diamonds, the pipe, when found, must be very rich, is entirely erroneous, and based on wrong ideas of the genesis of the pipes and dykes. On rich fissures we may find very poor pipes, and *vice versa* rich mines may lie on blank fissures.

ORIGIN OF THE KIMBERLITE MAGMA.

Before concluding this paper, I should like to make a few remarks on the origin of the kimberlite magma. It is a fact that the kimberlite pipes and dykes are distributed in quite an erratic manner throughout South Africa and other parts of the world—Central Africa, America, Australia.

Sometimes it appears as if diamondiferous belts were running through the country, and that these belts run parallel. Now the kimberlite magma is so characteristic that we must assume that all these occurrences have a similar origin. I cannot believe in those peripheric volcanic hearths which, nearer to the surface of the earth, from time to time got, and still get, occasion to extrude their magmas. I think that at a certain depth all rocks are under such a pressure that they must lose their original structure; they are in a superheated state, and when the pressure is relieved the melting point will be reached, and extrusion will take place.

There must be at certain depths such a zone all over the world—a *zone of reconstruction.* It can be readily imagined that in this zone of reconstruction rocks of varying composition occur in synclines and anticlines, and that, therefore, the zone of reconstruction varies in character from an ultra-acid to an ultra-basic chemical composition.

We can very well assume that certain rocks which have a general chemical composition similar to that of kimberlite, lie under those diamondiferous areas at such a depth that they are in that superheated

Digitized by Google

state which, on the pressure being relieved, allows the extrusion. These original formations may be of sedimentary or magmatic origin; maybe they are even entirely unknown to us anywhere on the earth's surface, but they must have a composition chemically similar to that of kimberlite.

Such a zone of reconstruction would explain that, before the extrusion of the ultra-basic kimberlite took place, less basic magmas from the upper parts of the zone of reconstruction were extruded, such as dolerites, which sometimes show a high percentage of silica.

If we accept this theory, it seems to me that we can explain how such a characteristic magma as kimberlite found its way towards the surface with the erratic distribution which we know of over such large areas in Africa.

Digitized by Google

On a Collection of Permo-Carboniferous Plants from the St. Lucia (Somkele) Coal-Field, Zululand, and from the Newcastle District, Natal (Read 12th August, 1907).

By A. C. Seward, F.R.S.,
Professor of Botany, Cambridge.
Honorary Member.

[Plates VIII. and IX.]

The material which forms the subject of these notes was sent to me a considerable time ago by Mr. Anderson, the Government Geologist of Natal. I regret that a variety of causes have contributed to the long delay in their transmission to South Africa. The specimens were obtained from the following localities:—

i. St. Lucia (Somkele) Coal-Field, Zululand; from the first tributary of the Enseleni River, north-west of the Main Northern road.
ii. St. Lucia (Somkele) Coal-Field; from a locality south of Ingula Hill.
iii. Umlalaas Coal-Field, Zululand; from Inyezane Creek.
iv. Umlalaas Coal-Field; borehole.
v. Ramsay Colliery, Newcastle District.

A comparatively small number of species have been recognised. As frequently happens in the plant-bearing rocks of South Africa, and other regions of Gondwana Land, the genus Glossopteris is represented by a great

Digitized by Google

number of specimens, but by few distinct forms. The fossils are referred to the following species:—

Phyllotheca Zeilleri Eth., Localities I. and III.
Bothrodendron sp., cf. *Bothrodendron Kidstoni* Sew., Locality V.
Glossopteris indica Schimp., Locality II.
Glossopteris Browniana Brongn., Localities I., III., IV.; the majority of the specimens from Locality I.
Vertebraria indica Royle (Rhizome of Glossopteris), Localities II. and III.
Glossopteris retifera Feist., Localities I. and II.
Cordaites (*Noeggerathiopsis*) *Hislopi* (Bunb.), Locality V.

The First Report of the Geological Survey of Natal and Zululand contains an account by Mr. Etheridge[1] of the following plants obtained from the St. Lucia (Somkele) Coal-Field, Zululand:—*Glossopteris Browniana*, var. *indica*; *G. Browniana*, var. *angustifolia*; *G. damudica*, var. *stenoneura*; *G. retifera*; *Angiopteridium spatulatum*; *Phyllotheca Zeilleri* Eth. fil.

Mr. Etheridge has used the name *G. Browniana* in the wider sense in which I have also employed it in former papers. In view of the opinion expressed by Professor Zeiller,[2] after a critical examination of the type specimens of Brongniart, and for the sake of uniformity of nomenclature, it is desirable to retain both specific names; it must, however, be admitted that our attempts to define species of the genus Glossopteris on the venation characters of fragments are at best approximations to an unattainable ideal. Mr. Arber, in his valuable "Catalogue of the Plants of the Glossopteris Flora in the British Museum," has adopted Zeiller's nomenclature as regards the two forms *G. Browniana* and *G. indica*.[3] An example of the difficulty of dealing in a satisfactory manner with the forms of Glossopteris is afforded by the specimens which Etheridge assigns to Feistmantel's species *G. retifera*. This type is one of several which are characterised by the larger size of the meshes formed by the anastomosing secondary veins; it is, however, impossible to decide what range of variation in the size of the reticulum to allow within the limits of a single species. The choice of a name for these larger meshed forms is referred to in the description of specimens regarded as identical with the fragment described by Etheridge as *G. retifera*.

Phyllotheca Zeilleri Eth. fil. Pl. VIII., figs. 2, 3.

The specimens of Phyllotheca from the Somkele and the Umlalaas Coal-Fields consist of several stem-fragments and some fairly well preserved leaf-sheaths. The stems are characterised by comparatively broad inter-nodal ridges, while the leaves have long free segments united below into a sheath. Although examples of the genus are frequently met with in Permo-carboniferous rocks in India, South Africa, and elsewhere, the material is too meagre to admit of satisfactory specific diagnosis; we know

[1] Etheridge (01); also Anderson (01).
[2] Zeiller (96).
[3] Arber (05*).

Digitized by Google

nothing of the fructification of the representatives of the genus in the Glossopteris flora, and our knowledge of the vegetative organs is exceedingly small. We must therefore admit the impossibility of determining species with any degree of certainty. The specimens represented in pl. VIII., figs. 2 and 3, consist of incomplete leaf-sheaths bearing filiform segments of the type already described by Etheridge from the St. Lucia Coal-Field.[4] The free parts of the leaves are filiform and slightly convex; in the basal collar the individual leaves are rather broader and flatter. It is unnecessary to give a detailed account of the species, as this has already been done by Mr. Etheridge.[4] The Zululand species is possibly identical with *P. australis*, as figured by Feistmantel[5] and others; it would also be difficult to point to any clearly defined distinction between *P. Zeilleri* and some of the examples of the genus figured by Schmalhausen[6] from Russian strata described by him as Jurassic, but which Zeiller[7] has since recognised as Permian.

Bothrodendron sp., cf. *Bothrodendron Kidstoni* Seward. Pl. VIII., figs. 1a, 1b.

On a piece of black shale from the Ramsay Colliery, Newcastle, two small fragments of an impression occur which are in all probability pieces of a stem very closely allied to, if not identical with, casts from Vereeniging, which have been named *B. Kidstoni*.[8] In the Newcastle specimens, which are much smaller than those on which the species is founded, the preservation is fairly good; the surface of the stem shows numerous fine discontinuous striæ, as on the stems of the European species, *Bothrodendron minutifolium* (Boul.).[9] The leaf-scars are from 1·3 to 1·5 mm. wide, and an indication of a central depression or vascular scar can be seen in some of them. This fragment is interesting as affording a second example of the genus from South Africa, and one in which the minute surface features are more clearly preserved.

Fig. 1, pl. VIII., shows the size of the specimen, and illustrates the scattered arrangement of the slightly depressed leaf-areas; figs. 2 and 3, pl. VIII., show the form of the scars and the wrinkling of the stem surface.

Glossopteris indica Schimp. Pl. IX., fig. 1.

Several pieces of shale from the Somkele Coal-Field are full of portions of fairly large fronds of this species, thus affording another instance of the extraordinary abundance of the genus in Lower Gondwana rocks. Glossopteris must have occupied large tracts of ground, almost to the exclusion of other plants.

This species is also recorded by Etheridge from the same coal-field.[10]

---

[4] Etheridge (01), p. 72.
[5] Feistmantel (90), pl. 14.
[6] Schmaulhausen (79), pls. ix.-xi.
[7] Zeiller (02).
[8] Seward (03), p. 87.
[9] Kidston (01), p. 86; *cf.* also *Bothrodendron Kitorkense*, figured by Nathorst (94), pl. xiv., from Lower Carboniferous rocks of Blar Island in the Arctic regions.
[10] Etheridge (01), p. 70.

Digitized by Google

In some of the specimens the fronds reached a length of more than 20 cm., with a breadth of 9 or 10 cm.; others are pieces of narrower leaves 14 cm. by 2·4 cm. The mid-rib is well developed; the lamina dies out gradually towards the broad end of the rachis, and the lateral veins are given off from the mid-rib at a wide angle, showing very clearly the long and narrow meshes characteristic of this species.[11] (Fig. 1; enlarged four times.)

Glossopteris Brouniana Brongn. Pl. VIII., figs. 4-7; pl. IX., figs. 2-4.

The specimens referred to of this species from the Somkele and Umlalaas Coal-Fields, consist of pieces of smaller fronds than those of *G. indica*. They include scale-leaves (fig. 6), small foliage-leaves (fig. 5), and sporangia identical with those figured by Mr. Arber, from New South Wales.[12] A group of sporangia, natural size, is seen in pl. VIII., fig. 7. A comparison of the enlarged drawing (fig. 7a) with those given by Mr. Arber, who first discovered these bodies, leaves no doubt as to the very close agreement between the Zululand and the Australian specimens. I have not been able to recognise any smaller bodies which can be regarded as spores. We cannot say whether Glossopteris was homosporous or heterosporous; it is possible that this genus, like so many of the northern palaeozoic plants, may have produced microspores in comparatively small sporangia, and integumented megaspores or seeds, but we have as yet no justification for describing Glossopteris as a pteridosperm.[13] The small laterally winged seed represented natural size in pl. VIII., fig. 2, and enlarged in fig. 2a, occurs in close association with the leaves of this species, and may belong to the same plant.

The fragment of frond from the borehole in the Umlalaas Coal-Field (Loc. IV.), represented in fig. 4, pl. VIII., shows the venation particularly well. The form of the meshes is seen more clearly in text fig. 2.[14] The leaf shown in fig. 5 is one of several examples of small fronds referred to this species. The shorter and relatively broader type (fig. 6; enlarged three times), agrees with the scale-leaves figured by Zeiller[15] from South Africa and by myself from New South Wales.[16]

The venation shown in pl. IX., fig. 3, was drawn from a slightly larger leaf than that represented in pl. VIII., fig. 5. The small scars on the broad mid-rib probably mark the position of fine ramenta or hairs. Fig. 4 shows part of the reticulum of another frond. A comparison of figs. 3-5, pl. IX., reveals the existence of certain differences in detail, *e.g.*, as regards the size and form of the meshes next the mid-rib; but all conform to one type.

Vertebraria indica Royle. Pl. VIII., figs. 9, 9a.

The best example of the rhizome occurs in association with the leaves

[11] Zeiller (96), p. 367; also Arber (05*), p. 66.
[12] Arber (05), (05*).
[13] For an account of Pteridosperms, see Scott (06).
[14] *Cf.* Zeiller (96), p. 363.
[15] *Ibid.*, pl. 16.
[16] Seward (97), pl. 23; also Arber (05*), pl. 2.

Digitized by Google

of *Glossopteris Browniana*. This specimen, represented in fig. 9, has a length of 9·3 cm. and a maximum breadth of 2 cm. In the upper part of the axis there are two series of slightly convex regions separated by narrow grooves, both longitudinal and transverse; towards the lower end there are three series of raised areas rather smaller than those at the upper end, as shown in the drawing. Under a low magnification the surface of the cast exhibits fine and irregularly longitudinal striations, which are no doubt the impressions of fibrous structure in the original stem; the short horizontal lines seen in the enlarged drawing are probably the result of contraction of the tissues on drying. Numerous fragments of Vertebraria are associated also with fronds of *G. indica* from the Somkele Coal-Field, but the material is insufficient to demonstrate any difference of importance between the rhizomes associated with the two species of Glossopteris. In several cases the stems have slender roots attached to them, which in some instances have the form of narrow forked appendages spreading on all sides from a vertical axis. The Vertebraria specimens do not throw any fresh light on the nature of the stem, which it is generally agreed bore Glossopteris leaves. Professor Zeiller's interpretation of the surface features of Vertebraria is the best so far suggested;[17] but we still lack specimens well enough preserved to raise his ingenious hypothesis to the rank of an established fact.

Glossopteris retifera Feist. Pl. VIII., figs. 8, 10; pl. IX., figs. 5, 6.

The name *Glossopteris retifera* was originally applied to Indian fronds, and afterwards to South African specimens obtained from the neighbourhood of Graaff-Reinet, in Cape Colony, characterised by highly-inclined secondary veins forming a reticulum of large meshes.[18] [19] Mr. Etheridge has figured a small piece of a frond from the Somkele Coal-Field as an example of Feistmantel's species. Among the fossils from Zululand submitted to me, some are undoubtedly identical with Etheridge's specimen, while others are characterised by a somewhat different inclination of the lateral veins and by a greater range of variation in the size of the meshes. As a matter of convenience, and in the absence of satisfactory data for the determination of differences which may be of specific rank, I prefer to adopt Feistmantel's term for the fragments of leaves which possess a venation reticulum considerably coarser than that of *G. Browniana* and *G. indica*. In addition to the species *G. retifera*, other large meshed forms have been named *G. conspicua* Feist.,[20] *G. Tatei* Feist.,[21] etc. Among the fronds figured by Feistmantel from India as *G. damudica*[22] there are some which appear to be indistinguishable from the Zululand fragments, but the photographs recently published by Prof. Zeiller[23] of the venation of leaves assigned by him to *G. damudica* are

[17] Zeiller (96), pl. 15.
[18] Feistmantel (89), p. 46.
[19] For references see Arber (05*), p. 83.
[20] Feistmantel (81).
[21] Feistmantel (89), pl. 4, fig. 8.
[22] Feistmantel (81), pls. 30a, 31a, 32a, 40a.
[23] Zeiller (02*), pl. 4, figs. 6 and 7.

Digitized by Google

characterised by a finer reticulum than that of the Somkele specimens. Mr. Arber regards *G. damudica* as identical with *G. ampla* Dana.[24] It is futile to look for satisfactory methods of discrimination between portions of Glossopteris leaves by means of comparatively trifling differences in the size of the meshes formed by the anastomosing of the secondary veins.

While admitting the hopelessness of the task, we must make use of specific designations in a sense which does not confine us within limits inconsistent with such variations as occur in fronds of recent ferns referred to one species. The chief distinction between *G. retifera* and *G. conspicua* mentioned by Mr. Arber in his "Synopsis of the Species of Glossopteris" is the greater elongation of the meshes in the latter species. An inspection of the camera lucida drawings, pl. IX., fig. 5, which were made from a small specimen of *G. retifera*, reveals a combination of the two types of mesh in the same lamina; the reticulum near the edge of the lamina conforms to that of *G. conspicua*, but in the lower part of their course the veins form meshes identical with those of *G. retifera*. The drawing shown in pl. IX., fig. 6, was made from the frond represented in pl. VIII., fig. 10. The veins of this specimen agree with those in the upper part of the specimen represented in pl. IX., fig. 5. The greater angle formed by the secondary veins with the mid-rib and the larger meshes in the neighbourhood of the mid-rib, as shown in fig. 6, do not afford an adequate reason against the inclusion of both specimens under one name.

The specimen represented in pl. VIII., fig. 10, must have formed part of a frond at least 25 cm. long and 10 cm. broad. The mid-rib is prominent, and continued to the apex; the meshes of the reticulum vary considerably in length, from 5 mm. to 1·5 or 2 cm., with an average breadth of approximately 1 mm. Fig. 8, pl. VIII., represents a fragment of a leaf in which the secondary veins are almost at right angles to the mid-rib as in *G. Tatei* Feist.,[25] which is characterised by the possession of still larger meshes.

Cordaites (*Noeggerathiopsis*) *Hislopi* (Bunb.).

Although it cannot be said that there is any absolute proof of the identity of Noeggerathiopsis and Cordaites, there is little doubt that the parallel veined leaves which occur abundantly in the Lower Gondwana of India and in the Ecca and Beaufort beds of South Africa, as well as in South America and Australia, may be regarded as the foliage of a member of the Cordaitales. Such evidence as we possess tends to support the view that Noeggerathiopsis and Cordaites are generically identical. The only fragment of the species in the collection is a piece of leaf from the black shale of the Newcastle district, 7·5 cm. long and 2·4 cm. broad; the lamina tapers to a narrow base and shows numerous slightly spreading veins.

Conclusion.—The coal-bearing strata of Natal and Zululand have so far afforded a comparatively small number of plants, and the evidence is too meagre to serve as the foundation for dogmatic statements as to the

[24] Arber (05*), p. 78.
[25] Feistmantel (89), pl. 4, fig. 8, p. 44.

Digitized by Google

precise horizon of the Permo-carboniferous system to which the beds should be referred. Mr. Anderson[26] includes the coal-bearing rocks of Natal and Zululand in the Ecca Series, thus differing from Molengraaff's conclusions; Mellor[27] deals with the question of the age of these rocks in his important paper on the position of the Transvaal coal measures, and expresses his dissent from Anderson's views. He assigns the strata to the Middle Karroo or Beaufort Series. This is also the view held by Kynaston.[28] The fossil plants hitherto recorded from Natal and Zululand[29] on the whole support the reference of the coal-bearing strata to the higher horizon, and the species described in this paper cannot be said to furnish a decisive answer in favour of the inclusion of the Zululand beds in the Ecca Series. The apparent absence of Gangamopteris affords reason for the choice of the Middle Karroo as the more probable horizon. The occurrence of Bothrodendron in the black shales of the Newcastle district suggests the possibility that these beds may belong to the Ecca Series, but until we possess more complete records it is almost impossible to arrive at a satisfactory conclusion. The species described above are distributed as follows:—

St. Lucia Coal-Field: *Phyllotheca Zeilleri*, *Glossopteris indica*, *G. Browniana*, *G. retifera*.
Umlalaas Coal-Field: *Phyllotheca Zeilleri*, *G. Browniana*.
Newcastle District: *Bothrodendron sp.*, *G. indica*, *Cordaites* (*Noeggerathiopsis*) *Hislopi*.

EXPLANATION OF PLATES.

Plate VIII:—

Fig. 1.—*Bothrodendron sp.* (nat. size).
„ 1a, 1b.—Leaf scars enlarged.
Figs. 2 and 3.—*Phyllotheca Zeilleri* Eth. junr. (nat. size).
Figs. 4 and 5.—*Glossopteris Browniana* Brongn. (nat. size).
Fig. 6.—*Glossopteris Browniana* Brongn. (× 3).
Fig. 7.—Sporangia of *G. Browniana* (nat. size).
„ 7a.—Sporangia of *G. Browniana* (× 12).
Fig. 8.—*Glossopteris retifera* Feist. (nat. size).
Fig. 9.—*Vertebraria indica* Royle (nat. size).
„ 9a.—*Vertebraria indica* Royle (part of surface enlarged).
Fig. 10.—*Glossopteris retifera* (nat. size). [Venation shown in pl. IX., fig. 6.]
Fig. 11.—Winged seed (nat. size).
„ 11a.—Winged seed (× 8).

[26] Anderson (01), p. 83.
[27] Mellor (06).
[28] Kynaston (06), p. 51.
[29] Etheridge (01); also Seward (04).

Digitized by Google

Plate IX. :—

Fig. 1.—*Glossopteris indica.* Camera lucida drawing considerably reduced; reproduced four times nat. size. M = mid-rib.

Figs. 2-4.—*Glossopteris Browniana* :—

Fig. 2.—Part of the venation of the fragment shown in pl. VIII., fig. 4, from the Umlalaas Coal-Field boring (× 4).

Fig. 3.—Part of a larger frond, with pits on the broad mid-rib. (× 4.)

Fig. 4.—Venation of slightly larger frond than that from which fig. 3 was drawn (× 4).

Figs. 5 and 6.—*Glossopteris retifera* :—

Fig. 5.—The camera lucida drawings were made from an incomplete portion of a lamina measuring 2·5 cm. from the torn edge to the mid-rib. The lower part of the figure shows the broader and shorter meshes near the mid-rib in contrast to the longer and narrower meshes near the edge of the lamina, represented in the upper part of the drawing. (× 4.)

Fig. 6.—Part of the venation of the specimen represented in pl. VIII., fig. 10. (× 4.)

BIBLIOGRAPHY.

Anderson, W. (01).—First Report of the Geological Survey of Natal and Zululand. Pietermaritzburg (1901).

——— (04).—Further Notes on the Reconnaissance Geological Survey of Zululand. Second Report, p. 39.

Arber, E. A. N. (05).—On the sporangium-like organs of *Glossopteris Browniana.* Quart. Journ. Geol. Soc., LXI., p. 324.

——— (05*)—Catalogue of the Fossil Plants of the Glossopteris Flora in the Department of Geology, British Museum, London (1905).

Etheridge, R. junr. (01).—Notes on Fossil Plants from the Saint Lucia Coal-Field, Enseleni River, Zululand. First Report of the Geological Survey of Natal and Zululand.

Feistmantel, O. (81).—The Flora of the Damuda and Panchet Divisions. Foss. Flor. Gondwana System. Mem. Geol. Surv. India = *Pal. indica,* ser. XII.

——— (89).—Uebersichtliche darstellung der Geologisch-Palaeontologischen Verhältnisse Süd-Afrikas. Abh. k. bohm. Ges. Wiss. Prag. VII. Folge, Bd. 3.

——— (90).—Geological and Palaeontological Relations of the Coal and Plant-bearing Beds of Palaeozoic and Mesozoic Age in Eastern Australia and Tasmania. Mem. Geol. Survey, New South Wales, Palaeont., No. 3.

Kidston, R. (01).—Carboniferous Lycopods and Sphenophylls. Trans. Nat. Hist. Soc., Glasgow; vol. VI., pt. I.

Digitized by Google

Kynaston, H. (06).—The Geology of the Komati Poort Coal-Field. Transvaal Mines Dept. Geological Survey, mem. 2.

Mellor, E. T. (06).—The Position of the Transvaal Coal-Measures in the Karroo Sequence. Trans. Geol. Soc., S. Africa, vol. IX., p. 57.

Nathorst, A. G. (94).—Zur Paläozoischen Flora der Arkfischen Zone. K. Svensk. Vet.-Akad. Hand. Bd. 26, No. 4.

Schmalhausen, J. (79).—Beiträge zur Jura-Flora Russlands. Mém. Acad. Imp. Sci. St. Pétersbourg; vol. XXVII. [7], No. 4.

Scott, D. H. (06).—The Present Position of Palaeozoic Botany. Progressus rei Botanicae, vol. I., p. 139.

Seward, A. C. (97).—On the Association of Sigillaria and Glossopteris in South Africa. Quart. Journ. Geol. Soc., vol. LIII., p. 315.

——— (03).—Fossil Floras of Cape Colony. Ann. S. African Mus., vol. IV.

——— (04).—Report on Collections of Natal Fossil Plants. Second Report, Geol. Surv., Natal and Zululand, p. 97.

Zeiller, R. (96).—Etude sur quelques plantes fossiles des environs de Johannesburg. Bull. Soc. Geol. France, vol. XXIV. [3], p. 349.

——— (02).—Nouvelles observations sur la flore fossile du Bassin de Kousnetzk (Sibérie). Compt. Rend. CXXXIV., p. 887.

——— (02*).—Observations sur quelques plantes fossiles des Lower Gondwanas. Mem. Geol. Surv., India = *Pal. indica*, vol. II.

Digitized by Google

Gneiss Formation in Africa (Read 12th August, 1907).

By F. W. Voit.

[Plate X.]

In my papers on this subject and the subsequent discussions, published in the Transactions of this Society on September 4th,[1] October 30th,[2] and November 20th,[3] 1905, I maintained that large areas of gneissoid rocks on both sides of the Limpopo River cannot be classed with the granites intrusive in the Swaziland Series, or with the latter formation itself. The question at issue is: Are these gneissoid rocks on the Limpopo simply foliated varieties and segregations of the intrusive granites, and therefore of the same age, or do they constitute a separate and older formation?

The Limpopo formation consists of two distinct facies of granitic rocks, each of which is of undoubted igneous origin. One facies consists of well-foliated, coarsely crystalline rocks, in which the typical gneissic foliation is particularly well developed; and its chief representatives are amphibolite schists, with hornblende, augite, garnet, magnetite, etc., gneisses. The other facies consists of granites which are mostly of a uniform crystalline character, and resemble the intrusive granite of the Swaziland Series. This granite is apparently also intrusive in the above-mentioned gneisses, a phenomenon which can be very often observed in the steep banks of the Limpopo River. We can easily identify this granite with that, in the neighbourhood of Pietersburg, between Johannesburg and Pretoria, and in Swaziland, etc. Areas of undoubted Swaziland beds, schists, quartzites, serpentines, etc., are frequently found in this granite, and in addition there can be observed inclusions of rounded and sharp-edged pieces of crystalline, and well-foliated rocks which do not

[1] "Preliminary Notes on Fundamental Gneiss Formation in South Africa."
[2] "Gneiss Formation on the Limpopo."
[3] "Additional Remarks on Gneiss Formation on the Limpopo."

Digitized by Google

belong to the Swaziland Series, and are apparently in no way related to the granite. These inclusions have been generally considered to be segregations of the granitic magma, and it may be admitted that the difference in chemical composition between, say, a very basic pyroxenite fragment and the enclosing very acid granite, would not stand in the way of this explanation. If, however, we find inclusions of a very coarsely-grained rock, particularly well foliated, in the interior of a very coarsely crystalline hornblende-felspar rock of undoubted granitic origin, we can under no circumstances explain that difference in the structure if we look upon them as segregations. Only recently, on a visit to the Pongola River, to the north of Vryheid, I found many fragments of a dark-green, very coarsely-crystalline, but well-foliated hornblende rock with very little felspar; in another instance an absolutely round boulder of augengneiss in the granite, which is an aggregate of orthoclase and quartz, with more or less mica. These coarsely crystalline inclusions in our old granite resemble very closely members of the gneiss-formation of the Limpopo, and I cannot consider these inclusions either as segregations or as members of the Swaziland Series, but as metamorphosed masses brought from a deeper-lying formation by the intruding granite.

On the Limpopo the stratigraphical relation between the Swaziland Series and the gneiss-formation can nowhere be defined, but as we find enormous stretches of Swaziland beds in South Africa, in no case overlaid by gneisses, they both must be older than the granite. It is probable that this gneiss-formation is older than the Swaziland Series, and forms our fundamental formation, just as foliated rocks of gneissic character underlie our oldest sedimentary beds elsewhere on the earth's surface.

Drs. Sandberg and Jorissen once imputed to me the belief in an urgneiss formation forming the earth's crust, or that I maintained that the gneisses must always be of the very oldest origin. I once, en passant, mentioned that the fundamental gneiss-formation on the Limpopo might belong to the original solidified crust of the earth, seeing that we have such an unusually old continent, where the thickness of the formations, younger than the Archæan, is, relatively speaking, very small, and where it may be, that the very oldest rocks were never covered by sedimentary beds; but my publications certainly prove that, with regard to igneous rocks, I rather adhere to the theory of rocks having been reconstructed at depths and extruded. In fact, I do not see why, for instance, these rocks, forming our old intrusive granite, should not be derived from a certain horizon, which, in the earth's history, is even older than our fundamental formation. Of course, I think it is perfectly within the range of possibility that we should have gneisses, in the lithological sense of the word, at any horizon, as we know to be the case with the tertiary granites.

With regard to the existence of gneiss-formation in other parts of Africa, the reports of the geologists in German East Africa are of great interest.

The following remarks are taken from a paper read by Mr. Tornau before the "Deutsche Geologische Gesellschaft," in Berlin, on March 6th, 1907:—

"In his geological map of German East Africa, 'Dantz' maps the

Digitized by Google

central and northern parts of the Colony as an enormous area of gneiss, in which he makes a difference between the peripheric zones of gneiss, of particularly well foliated character, and the central part, of granitic character." In other words, there is a central granitic axis which is flanked by gneisses; we will see later on, that this phenomenon is repeated in the Engoye Mountains in Zululand. Tornau further states that in the Uluguru Mountains he noticed gneisses of every variety, but that generally in other parts of the Colony through which he travelled, coarsely-grained granites prevail, showing throughout the same uniform composition and character, without any signs of foliation, and this he calls typical granite, identical, no doubt, with our intrusive granite.

He states that the gneisses are older than the granite; for instance, he found towards the south of the Nyassa rounded gneiss-fragments of all varieties, with sharp contours in the granite, and these he calls boulders (broken gneiss). On the other hand, it is possible that the foliated character of part of the granite might be due to the influence of pressure. It is very interesting to observe that, as the granite is intrusive in the gneisses and also in the Swaziland Series, gneiss and granite are mixed up, so to say, and we will have to differentiate between areas consisting chiefly of granites and those where gneisses mostly prevail, just as is the case in areas where the Swaziland Series is chiefly in evidence, and those in which the granites preponderate. The same granite is intrusive in both formations, and according to the preponderance of the one or the other we have to map certain areas as granite, or gneiss, or Swaziland Series.

Once, when travelling in Angola, I found it necessary to distinguish between granite and very coarse-grained gneisses, in which the granite was intrusive, and it may be remarked that these gneisses show a remarkable resemblance to the foliated gneisses of the Limpopo. It further appears that certain gneisses, south of the Gansberg, described by me in my paper "Contributions to the Geology of German South-West Africa" (Transactions of the Geological Society of South Africa, 1904, page 77), as foliated granites, ought to be separated from the intrusive granites and classified as an independent formation. It is interesting to the geologist, who has seen more of Africa than the south, to observe, that with regard to the distribution of gneisses with intrusive granite, on the one hand, and the Swaziland Series (or Malmesbury Beds) with intrusive granite, on the other, the latter seem to prevail in the South of Africa, while, proceeding towards Rhodesia and Central Africa, the gneisses and granites apparently predominate.

Some time ago I was able to study this same formation in Zululand, to the south of 'Nkandhla. I quoted Mr. W. Anderson, late State Geologist of Natal, in my "Additional Remarks on Gneiss Formation on the Limpopo" (Transactions, Geological Society S.A., 20th November, 1905). Mr. Anderson divides the geological formations of Natal as follows:—

Fundamental gneisses and schists.
Intrusive granite.
Barberton Series of Swaziland (identical with Swaziland Series).
Hospital Hill Series (identical with Witwatersrand Series).

Digitized by Google

With regard to the Engoye Mountains, I was able to verify Mr. Anderson's statements. The axis of the mountains consists of intrusive granite, flanked on both sides north and south by gneisses dipping from the granite, an excellent parallel with the statements of Mr. Dantz regarding German East Africa, as mentioned above.

In discussing my paper at the meeting of the Society on September 4th, 1905, Mr. H. S. Harger identifies a formation of ancient crystalline schists on the border of Natal and Zululand, near Krantzkop, with the formation on the Limpopo.

Certainly in Zululand, in consequence of the enormously eroded character of the country, the older formations, and their relations to each other, can be studied better than in other South African areas, and I think that the accompanying sketch-section is of great interest.

Passing from 'Nkandhla to the south, we first come upon the Swaziland Series, dipping nearly vertically, overlaid by patches of Dwyka-conglomerate and Ecca-shales, and in the Swaziland Series conglomerates and quartzites are found. They resemble very closely those of the Witwatersrand Series, the conglomerates showing throughout quartz pebbles, and the quartzites being very fine-grained. These conglomerate and quartzite beds dip at very high angles, and are at times vertical. In the latter case they seem to be conformable with the Swaziland Series; but on following their outcrop one finds them bending round and round till their strike lies at right angles to the abutting Swaziland Series, which for long distances keep their east and west strike. In fact, these quartzites and conglomerates are very often found in Zululand forming basins in the Swaziland Series. A beautiful example of the unconformability of the two series is shown in the sketch section.

Towards the south, through the whole of the 'Nkandhla bush, the rocks consist of intrusive granite with areas of the Swaziland Series, especially Itabirites, near the Sibudeni Store. South of the Sibudeni Store, the Umysuana River, a tributary to the Umhlatuzi, has cut a deep gorge apparently along an extensive fault running east and west. South of that fault a formation of particularly well-foliated, highly-crystalline rocks, such as hornblende and augite-schists and gneisses, with garnet-gneisses, etc., can be studied. There is a marked similarity between this formation, dipping at an angle of about 10 degrees south, and the gneisses upon the Limpopo, with which I have no hesitation in correlating it. Hundreds of granite veins, of various sizes, undoubtedly the intrusive or old grey granite, break through this formation. Further south the country is covered again by younger formations, but on the road from Melmoth to Eshowe large areas consist of granite in which many rounded masses of the same hornblendic and augen-gneisses can be found.

Here again the difference in the foliated character of the metamorphic areas and the crystalline character of the granites, whose constituent minerals are arranged without any regularity, is very marked, and one can often observe how these gneissic masses, well foliated in the interior, lose their banded character towards the periphery and pass into a densely-grained rock; fine examples of contact metamorphism, on inclusions of basic rocks, in an enclosing acid magma. Similar phenomena can be

Digitized by Google

observed in the granite near the Umhlatuzi Crossing, on the road from 'Nkandhla to Melmoth, as Mr. Anderson informed me.

In concluding these remarks, I should like to point out that we have two distinct formations in which our older granite is intrusive—one a coarse-grained, highly-crystalline rock of well-foliated character, which is similar to the very oldest gneiss of Laurentian age, and of undoubted igneous character; the other, the Swaziland Series, of undoubted sedimentary character with igneous sheets of diabasic rocks.

I admit that so far no evidence has been put forward regarding the sequence of the gneisses and the Swaziland Series, but in Zululand, at least, such a marked difference in dip, forcibly suggesting unconformability between the two formations, can be observed, that there seems little difficulty in deciding which of the two formations—gneiss or Swaziland Series—is the older.

Digitized by Google

On the Supposed Kimberlite Magma and Eclogite Concretions (Read 14th October, 1907).

By T. G. Bonney, Sc.D., F.R.S., &c.

Honorary Member.

As my name is unavoidably mentioned several times in the papers by Messrs. G. S. Corstorphine and F. W. Voit, recently read to your Society, I ask leave to state my reasons for dissenting from their conclusions. As each maintains the matrix of the various minerals diamond, garnet, pyroxene, etc.—found in the "blue ground," or so-called kimberlite—to be a solidified magma, I will deal first with this general question. In that, however, I shall be brief, though the idea was strongly advocated by the late Professor Carvill Lewis, because I have already stated in print the reasons why I cannot accept it.[1] The matrix of the "blue ground" (I speak of the less decomposed specimens) does not resemble any igneous rock with which I am acquainted. That, it may be said, is because the rock has undergone so much secondary change the formation of calcite, dolomite, or serpentine, and in some cases of a minute biotite, the carbonates often amounting to about a sixth, and the serpentine to quite half of the whole mass. The difficulty, however, is not removed by making allowance for this. Omitting the amount of H_2O and CO_2 from the analysis given by Lewis[2], and re-calculating the other constituents, we have approximately SiO_2 37·9, Al_2O_3, etc. 13·7, $MgO = 37·1$, $CaO = 11·0$, $Na_2O = 0·7$. Total 100·4. In this the percentage of silica is too low, that of magnesia too high, for a troctolite or a picrite, and the quantities of alumina, iron and alkalies are insufficient for a mica-peridotite; the silica will not allow of the CaO being present in an augite, and if we assume olivine to be the chief constituent, even supposing that to be monticellite, there would not be enough silica left to combine with the alumina and remaining lime as anorthite.

[1] *Proc. Roy. Soc.*, vol. lxv., p. 235.

[2] *The Genesis of the Diamond*, p. 47. I have chosen this (though obviously an imperfect analysis) because it is more favourable to his view than that made for myself (*Proc. Roy. Soc.*, vol. lxvii. p. 480), and I prefer one where I am sure that I know the rock. The latter approaches (though with important differences) that of a melilite-basalt, to which, however, the rock has no structural resemblance.

Digitized by Google

Thus Lewis' suggestion that kimberlite was a porphyritic glassy peridotite is negatived, not only, as I have elsewhere pointed out, by the fact that large masses of glass are unknown in the very basic rocks, but also by the analysis itself.

From the general question, I turn to some of the more important details. Dr. Corstorphine admits that the "eclogite boulders" from the Roberts-Victor Mine are "spheroidal or ellipsoidal in shape, many, however, being incomplete, having obviously been broken across," as was the case with some described by myself from the Newlands Mine.[3] He also states that three explanations may be given of their presence in the diamantiferous matrix: (1) They are water-worn boulders, which were once part of a conglomerate, whence they have been scattered by the volcanic explosions; (2) they may be pieces of a basic igneous rock, altered into eclogite by metamorphism in the pipe; (3) they may be concretionary nodules formed in the original matrix of the blue ground or kimberlite. Of these we need not discuss the second, since Dr. Corstorphine himself rejects it for reasons which, though others might be added, are, I think, amply sufficient.

I pass, then, to his objections to the first explanation (the one which I prefer). In dealing with these, I must point out that he is not quite accurate in stating that I "held that not only the diamond, but the diopside and the garnet, of the pipe originated from an eclogite or related rock." As regards the second and third mineral, this is correct, but I expressed myself more cautiously about the first. My words are: "Thus the diamond has been traced up to an igneous rock. . . . . *i.e.*, is a constituent of the eclogite just as much as a zircon may be a constituent of a granite or syenite. Its regular form suggests that it was the first mineral to crystallize in the magma, but also a further possibility." Then, after giving some reasons why I should hardly have expected to find it in a rock of that chemical composition, I continue: "Can it possibly be a derivative mineral, even in the eclogite? Had it already crystallized out of a more basic magma, which, however, was still molten when one more acid was injected and the mixture became eclogite?" But this, as I point out, is conjecture, while the diamond is proved to be a constituent of the eclogite, "which rock, according to the ordinary rules of inference, must be regarded as its birth-place." In fact, I have always anticipated that the conjecture would some day become a reality, and in writing the "conclusion" from which I have quoted, was careful not to close the door against it, which, I maintain, is not done by the last sentence, unless it be dissociated from the context.

To proceed, then, to the objections. The absence of eclogite from South Africa and in the pebbles of the Dwyka conglomerate are negative arguments, which, though not without some weight, may at any moment be demolished. The former is generally a rock of rather limited and local occurrence, and in the neighbourhood of the mines, both it and the conglomerate (assuming their existence) lie far below the surface. Another objection seems to me still less formidable: "As to eclogite being the parent rock of the diamond, it is strange, if this be so, that

[3] *Proc. Royal Soc.*, vol. lxv., p. 223, lxvii., p. 475.

Digitized by Google

no eclogites elsewhere have been found to contain diamonds." Do they —or igneous rocks in general—at all commonly contain carbon, without which we cannot have either diamond or graphite? The gem recently, as Professor David has shown us, has been detected in a diabase; to this, also, *mutatis mutandis*, Dr. Corstorphine should make the same objection. But I am afraid I should not regard it as formidable, because I not only know my friend to be one of the most cautious of observers, but also have myself seen the specimens.

I pass on, then, to the third or "concretion" hypothesis, which commends itself alike to Dr. Corstorphine and Dr. Voit. The former finds "unwitting support" for his hypothesis in a miner's statement that the "nodules" were very abundant in the "yellow ground," but were absent from the "blue ground," which, however, seems to me a very unsound prop, since he himself argues for their presence in the latter, and ignores the fact that those in the Newlands Mine occurred in it. That the diamond crystals often show no signs of attrition, which seems to him a difficulty, is not surprising when we remember that this mineral is harder, and commonly much harder, than all the materials with which it is associated, while the fact that so many of these crystals are either in a state of great strain or are true fragments (of which the great Cullinan diamond is a noted example) is very difficult to explain on the "concretion hypothesis."

Here, again, are some arguments which do not strike me as formidable. "We cannot imagine that fragile minerals have come from great depths, as in this case they would have been crushed to atoms in the ascending magma." But I defy either author to prove the kimberlite to have been a magma. Or, again, "if these large aggregates of mica, garnets, etc., sometimes as large as a man's head, come from great depths, say from the crystalline schists, where can we find such enormous thick beds of pure garnet and mica rock?" Nowhere, of course, except in Dr. Voit's imagination. No one has supposed, or needs to suppose, that they ever existed. To continue: "One would expect that these minerals, in at least a few cases, were connected with felspar or quartz." Then, I ask, if they were local concretions from the magma, why do we not find in it plenty of felspar and quartz? It ought to have become richer in these, as a consequence of the separation of the other minerals. But we do find in it garnet, enstatite, diopside, olivine, and tolerably abundant iron oxides—minerals which are not necessarily associated with felspar and quartz. Iron oxides and spinellids are only common in the most basic rocks; garnet and diopside form a normal eclogite, in which quartz or felspars are only accidental; olivine with or without enstatite and diopside, occasionally also with a pyrope or a brown mica, makes the peridotites. The specimens of eclogite, saxonite, lherzolite, eulysite, etc., which I have examined from the "blue ground," are indistinguishable from those which I know to have come (having collected some of them myself) from ordinary masses, presumably intrusive, of igneous rock. Can it be proved that the structures of concretions are identical with those of corresponding igneous rocks of similar mineral composition? I have paid some attention to this matter, and venture to reply in the negative. We must not forget that in consequence of more accurate

Digitized by Google

methods of study many supposed concretions in igneous rocks have been transferred to the category of fragments, torn off other rocks, and sometimes partially melted down. I have examined not a few olivine nodules in basalts, and never saw one of any size which suggested a concretionary origin. They appeared to me as truly fragments as the pieces of trachyte, granite, gneiss, and more or less altered sedimentary rocks which I have seen in similar positions. Nor can we conjure with the mysterious word "Urausscheidungen," polysyllabic though it be.[4] Of this, also, I have studied instances, some of which, I grant, bear no resemblance to boulders or to ordinary enclosed fragments, but show a transition, though sometimes a rather rapid one, into the surrounding rock. That they may often be the results of an antecedent magmatic differentiation, I should not deny. To what extent, and from what causes, separation of constituents takes place in the molten material beneath the more solid crust of the earth, we do not yet precisely know, but that such separation does occur is almost certain. The one portion may then cool more quickly than the other, and become either a crystalline or a viscous mass, perhaps studded with one or two already crystallized minerals. In this condition it may, in consequence of earth movements, be broken up and carried along by the other portion. According to circumstances it may be locally melted down, thus altering the composition of the invader; or, if not yet crystalline, it may be softened, and the two drawn out in streaks, or it may be carried along in actual fragments, these being in any condition from vitreous to holocrystalline. The first may account for the gradual mineral changes occasionally exhibited in large rock masses of igneous origin; the second, for the distinct banding, mimicing stratification, which is even more common; the third, for the presence of fragments, sometimes with an external halo due to a slight melting of the exterior, but often with sharply-defined outlines, and rounded or angular in shape according to the nature of the rock from which they have been detached. This is, in my opinion, the history of the olivine "nodules" in sundry basalts and diabases. I am aware that certain differences have been indicated between them and ordinary peridotites, but these seem to me not sufficiently important to signify more than such differences in environment as may very well have existed (for instance, solidification before or after becoming an "inclusion"). When we find a lump of peridotite more than a couple of inches in diameter, either enveloped in a thin shell of basalt, as the core of a bomb, or embedded in that rock in the same way as a bit of granite, quartzite, or baked shale, I fail to see how the concretionary hypothesis is applicable, especially in the former case, or how we are to explain the sharp contrast at their junction between two rocks so very unlike in composition as peridotite and basalt (or, I might add, kimber-

[4] F. Zirkel, "Ueber Urausscheidungen in Rheinischen Basalten" (*Königl. Sachs. Gesell. der Wissensch. math. phys. Klasse.* xxviii., p. 103). I agree in the main with the view attributed to Lacroix (p. 115). This view supposed a separation of a large mass of intermediate character into two extremes: the other, a concentration in a very limited space of one material from another of a greatly different composition. The latter would have to take place with much greater rapidity; for the concentration could hardly begin till the molten material ceased to move, and after that, in all probability, it would quickly become solid.

Digitized by Google

lite). For a magmatic differentiation at an earlier stage of their history we can sometimes find indirect evidence. That a peridotite (or serpentine) is so often associated with an intrusive gabbro (which, allowing for any slight subsequent change, is chemically identical with basalt),[5] and that we sometimes find, as intermediate intrusives, either rocks consisting of almost pure enstatite (bastite) or augite (diallage), or else troctolite (a little more basic than gabbro), are suggestive facts, but this is a very different thing from a concretionary action in the ordinary sense of the term. It may, no doubt, sometimes occur, but that, as I have said, its results should be substantially identical with those of crystallization in mass, is contrary to all my experience. The principle of the origin of species works in petrology as in zoology; different environments produce different results, whether they act upon a mass of magma or a "plastic" form of life. One result, though in some respects exceptional, of concretionary action in an ordinary magma may be seen in certain "spheroid-bearing" granites[6] and in the orbicular diorite (Napoleonite) of Corsica.[7]

We may further ask whether any valid evidence exists of concretionary action producing in a compact igneous rock, even if it be porphyritic in structure, such coarsely crystalline masses as these eclogites and the bastitite (not to mention others) which I have described. But, as stated above, though agreeing with many details in Dr. Voit's paper on the origin of diamonds, I not only assert this could not occur, but also deny that kimberlite is a magma.

If I have spoken in the foregoing remarks somewhat dogmatically, I have at any rate taken considerable pains to qualify myself to form an opinion on these subjects. For some five and thirty years I have been studying petrology. My first paper on serpentine and its associates was published in 1877, and since then I have visited, at least once a year on an average, some locality where these rocks (including peridotites) could be examined. I have worked, and that frequently, both in the old volcanic districts of Britain and in the more recent examples of Auvergne, the neighbourhood of Rome and of Naples, the Eifel, Siebengebirge, and other parts of Germany.[8] I have paid particular attention for some four and twenty years to these questions of segregation and other differential structures in igneous rocks, whether compact or crystalline, and have done my best to acquire accurate knowledge by studying them not only in the field, but also under the microscope from specimens collected by myself, together with others, whether purchased or given,

[5] This also, using the term in a wide sense, not unfrequently cuts serpentine.

[6] For one example see F. H. Hatch, *Quart. Journ. Geol. Soc.*, vol. xliv., 1888, p. 548.

[7] For an explanation of the structure see my Presidential address, *Quart. Journ. Geol. Soc.*, vol. xli., 1885, p. 85. Dr. Voit cites rounded concretions of pyrite in support of his hypothesis, but he might just as well have appealed to 'cement stones' or septaria or 'pennystones'; for concretionary balls of pyrite form quite readily in chalk, but I never saw anywhere a mass of coarsely crystalline silicates under similar circumstances.

[8] I am glad to see Messrs. Corstorphine and Voit tacitly repudiate the rounding of these eclogite and other boulders by a sort of 'cup and ball' action in the volcanic pipe. To one who has really studied the ejecta of volcanoes or the contents of ancient necks such a hypothesis seems hardly to demand serious consideration.

Digitized by Google

from places which I was unable to visit. I have also tried to learn something about pebbles and boulders. I began more special work at them nearly thirty years ago, and in 1888[9] spent some time in observing the rounding of pebbles in Alpine rivers, since when I have never lost an opportunity of watching the effects of streams or waves on fragments of rocks. It is true that I have never visited the diamantiferous "pipes" of South Africa. The duties of life have made long absences impossible, and when the opportunity came, the number of years to be carried with me forbade a long and trying journey. But I have examined many specimens from this interesting region, having begun the study about sixteen years ago, and my cabinet contains, at least, five dozen representative slices. In short, either I have been for the best half of my period of scientific work chasing phantoms and dreaming dreams or the "magma" and "concretion" hypothesis is all wrong.

---

[9] *Geol. Mag.*, 1888, p. 54.

Digitized by Google

Further Remarks on the Kimberlite Rock and the Origin of Diamonds (Read 14th October, 1907).

By F. W. Voit.

Since I read my papers on these subjects I have had occasion to study microscopically a good many rocks from pipes and dykes, and the discussions on these papers have developed some new ideas, which I should like to bring before this Society.

So far, kimberlite has always been described as a serpentinous breccia; the serpentinized portion of the rock being altered olivine, the term "serpentinized peridotite breccia" has been generally accepted. The material filling the pipes was said to have been formed at great depths and brought to the surface by volcanic action. So far the rock itself, its occurrence and the way it came to the earth's surface, has been described as being unique, and as having quite an extraordinary and unusual genesis.

I must admit that the decomposition of the kimberlite has gone so far that it will be extremely difficult to come to a conclusion as to its true character; still, however, my investigations convince me that up to the present no justice has been done to the kimberlite rock, and that some extraordinary characteristics which certainly do exist, induced people to attribute such an unusual genesis to the kimberlite rock.

The slides which I examined are from specimens of pipe-rock near Kimberley, the Roberts Victor, Voorspoed, Regina, Lovedale, Monastery, Premier, Zonderwater, etc., and of dyke-rocks from Kimberley, Paardeberg, Prieska, Vulcan, Smaldeel, etc.

It is a characteristic of the pipe and dyke-rocks of one district that they resemble each other very closely, but they can easily be distinguished from similar rocks of other districts, so that we have a Kimberly type, a Roberts Victor type, a Premier type, etc. With regard to the description of some of the thin slides, selected as best preserved and given below, it will be seen that I laid stress only on three points—*viz.*, on the imputed brecciated character, due to the movement of a molten mass in an open crater containing minerals of a deep-seated origin, to the structure of the rock, and to the chief constituents building up the rock, whose presence gives the name to the rock. So far I have not gone into details with regard to the description of the various micas with their abnormal optical characters or other accessory minerals with similar abnormalities. A description of these I must postpone to a later period.

With regard to the term "peridotite," with which the kimberlite is

Digitized by Google

generally classed, I wish to point out that Harger first drew attention to the fact that in many cases pyroxene was undoubtedly prevalent in the rock. In the numerous slides examined, I did not find one in which the olivine occurred in such quantities that it would be justifiable to call the rock a peridotite.

With regard to the term "breccia," I have previously pointed out that the kimberlite might be called a breccia only with regard to the sometimes angular, sometimes rounded enclosures of foreign rock fragments, though I, for my part, would prefer the term "agglomerate." There are undoubtedly strong evidences of pressure in the rock in the shape of broken and bent minerals. In large specimens, as shown by Harger, I would attribute this phenomenon in greater part to secondary protrusions of the magma. The broken character, however, of phenocrysts of mica and pyroxene under the microscope is clearly due to serpentinization. The more serpentinized the rock is, the more we find the phenocrysts broken and bent.

A. L. du Toit mentions (Eleventh Annual Report of the Geological Commission of the Cape of Good Hope, 1906; the Diamondiferous and Allied Pipes and Fissures) that the increase in volume accompanying alterations of diopside into serpentine is 37 per cent., and the increase of a rock in density and bulk is frequently mentioned by R. Beck in his standard work on "Ore Deposits." No doubt this process of serpentinization is partly responsible for very many other phenomena, which up to the present were a stumbling-block to a sound solution of the kimberlite problem.

With regard to the structure of the rock, however, I would state that we have to do with a rock very similar to "Ganggestein"—*i.e.*, a rock standing between a plutonic and an effusive rock—that we have to do with a magma crystallized out *in situ* and under pressure. There are clearly two generations, and the rock is more porphyritic in pipes and more basaltic in dykes; all the minerals, however, have apparently crystallized out *in situ*, though occasionally crystallization during the ascension of the magma may have taken place, as we sometimes find under the microscope, corroded crystals. The great variety of accessory minerals may, to a certain extent, be due to the incorporation of a certain number of rock fragments of different chemical compositions in a magma of great resorbing capacity—in fact, I believe that the broken fragments of deep-seated rocks have been dissolved to a certain extent by the ascending magma, and in this way attained their rounded form. As a whole, however, this magma is a homogeneous, independent mass extruding from a certain source.

DESCRIPTION OF ROCKS.

1. Kimberley Mine (2,400 feet).—Large phenocrysts of pyroxene (diopside?) and some mica in a finely crystalline mesostasis of serpentine, probably also pyroxene, typical porphyritic structure. Pyroxenite porphyry.
2. Ditto.
3. Ditto.

Digitized by Google

4. Roberts Victor.—Pyroxene phenocrysts, much evidence of pressure, secondary green mica, mesostasis finely crystalline, all pyroxene (?). Typical porphyritic structure. Pyroxene porphyry.
5. Roberts Victor. (Fissure).—Augite phenocrysts (a few small olivines) in augitic mesostasis; structure more basaltic.
6. Voorspoed.—Pyroxene phenocrysts; structure porphyritic.
7. Prieska Diamonds. (Fissure).—Cryptocrystalline rock, all augitic, a few augite crystals; structure basaltic.
8. Paardeberg. (Fissure).—Size of crystals varying, apparently all pyroxene; basaltic structure.
9. Lovedale.—This mine contains plentiful segregations of a (microscopically) coarsely-crystalline diopside rock containing many garnets (eclogite) in a finely-crystalline diopsidic blue ground of very similar character. Under the microscope the segregations are a coarsely crystalline mixture of diopside and some enstatite, both strongly hydrated; garnets showing kelyphytisation; this rock gives to a certain extent the impression of a holocrystalline structure. The zone into which the segregation gradually passes is cryptocrystalline, and shows, besides serpentine, secondary sericitic mica.
10. Monastery.—Pyroxenite porphyry.
11. Regina. (Hardibank).—Large olivine phenocrysts in augitic ground-mass.
12. Premier Mine. Bore core 800 feet. Pyroxene porphyry. Containing small olivines.
13. Ditto.
14. Ditto.
15. Zonderwater.—Very much decomposed. Pyroxene phenocrysts; some olivines. Mesostasis serpentine; typical porphyritic structure.
16. Klein Zonderhout, 20 miles south of Premier. (Fissure.)
    (a) Augite crystals, fibrous by secondary products in augitic ground mass; basaltic structure.
    (b) Phenocrysts of augite (partly altered into mica) and Vaalite, felspar (?) including a mica, more porphyritic structure.

I must note that in examining the slides I got, in a few cases, a suspicion that felspar might be present. The decomposition, however, had gone so far that I doubt whether that point will ever be settled. Certainly I found in No. 16b a mineral which showed faint traces of polysynthetic twinning. There are orderly-arranged inclusions of a secondary highly-hydrated nature, which points to schillerisation. Still, however, I wish to say that nothing definite can be stated with regard to this point.

Digitized by Google

Characteristic of all these (and other more decomposed) slides was the absence of any glass which one would expect in a rock cooled down in an open crater. The difference in the structure of the pipe and the dyke-rocks is generally very marked, though a connection between these may exist (No. 16b). The difference of both structures may, no doubt, be due to the slow cooling down of the pipe-rock in a large cavity and the quicker cooling down of the dyke-rock between the narrow walls of a fissure. Then, however, we would expect towards the walls of the pipe a rather basaltic structure of the pipe-rock, similar to dyke-rock, which, however, is not the case. Nearly always a few feet from the walls the pipe-rock is simply found to be a hardibank, which in no way is different from the soft blue rock, except in the difficulty with which it disintegrates.

If microscopical examination does not give us a final result with regard to the relation of dyke to pipe-rock, so far field-evidence shows a marked difference between the two rocks.

Certainly we must break with the term peridotite, as the rock is much more likely to be a porphyritic pyroxenite. I am inclined to look upon the kimberlite as the final evidence of volcanic activity (in the largest sense of the word) which took place immediately after the Karroo period, beginning with the extrusion of very siliceous rocks of diabasic character, which we find in the lower beds of the Karroo formation. During the later eruptions these diabasic rocks take more and more a normal character till ultimately, in the extrusion of the kimberlite, they pass into an ultrabasic rock chiefly containing pyroxene as a constituent mineral (compare "Origin of the Kimberlite Magma.")

Field-evidence is apparently strongly in favour of this assumption, and everybody who has worked on the veld will have had the experience of uncertainty as to whether he should classify certain rocks as diabases or as kimberlite. There exists, for instance, some 60 miles due west of Kimberley on the Vaal River, about 200 yards from the river, a pipe on the farm De Bad which is partly laid open by denudation. The walls of the pipe are formed by Dwyka-conglomerate. The pipe-rock itself consists of serpentine throughout. Under the microscope nothing can be made out as to the original nature of the rock, which appears to have been of crystalline character. The forms of serpentinization would point to a fibrous pyroxene, possibly enstatite. But not one of the well-known accessory minerals is present, and even in washing large quantities, the incidental garnets and carbons are rare and of very small size. The foreign rock-fragments, however, such as granites, gneisses, schists, etc., are plentiful in this pipe. which is very poor in diamonds. If we have here on the one hand a kimberlite free of all the accessory minerals, and being simply a serpentinized pyroxenite, we find on the other hand occasionally large ilmenite segregations and numerous garnets in diabases. We may have occasionally rocks of diabasic character, belonging to the older horizons, containing even diamonds and many of the accessory minerals typical of kimberlite.

This latter point may turn out to be of great interest, as we then might expect to find diamonds in diabases and similar rocks in

Digitized by Google

Africa, as they are found in hornblende diabases in other countries,* and this possibility throws a new light on the occurrence of diamonds on many of the so-called alluvial diggings.

ELUVIAL DIAMOND DEPOSITS.

It is extraordinary how widespread the occurrence of the diamond is in South Africa; there are diamond-fields, as for instance the Vaal River, Pniel Estate, etc., far away from the river, up the high plateau, where the old river never flowed. We find diamonds, for instance, 25 miles north of Bloemhof, spread over a wide area where no alluvial gravel exists; we find diamonds near Christiana upon the heights where also no traces of an old river gravel is found. Here the diamonds are simply found in the decomposition products of the country rock, a very green, hard, sometimes amygdaloidal rock of diabasic character which, as felspar is inferior in quantity to pyroxene, would rather deserve the name of pyroxenite.

Generally the gravel of the so-called alluvial diamond-field, when it exists at all, is absolutely different from the gravel of modern rivers, and it is most likely that the diamonds have weathered out there *in situ* from diamondiferous diabasic rocks of different ages. We may assume, for instance, that the diamonds on the Harrisdale ground weathered from a now denuded kimberlite sheet, as we know by borehole results that extensive sheets of kimberlite, or a rock very similar to it, still exist on the ground. Some of those diamonds may weather out from diabase dykes (?), and there is a strong suspicion that the diamonds on the Pniel and Vaal River Estates have weathered, and still weather. from the amygdaloidal diabase underlying the Dwyka conglomerate. The many blue, black, yellow, brown-banded cherts, jaspers and ferruginous cherts, known as bantams, looking as if they were waterworn, have weathered out from the Dwyka conglomerate, and were concentrated *in situ*. After the removal of the Dwyka conglomerate the amygdaloidal diabases began to fall a victim to denudation, and here again a concentration of the heavier remainder, consisting of diamonds, ilmenites, agates, chalcedony and quartz amygdules, which are not so easily decomposed as the diabasic material, has taken place. There is a marked difference in the gravels of the present river alluvial deposits and the gravels of those eluvial deposits; furthermore, hard as the diamond is, it would show a good deal of attrition if it had travelled a long way, but in most cases these diamonds show sharp edges in the same way that stones from the pipes do. The contention has also been that the diamonds in these gravel deposits may come from an undiscovered pipe in the neighbourhood.

---

* "The Origin and Occurrence of the Diamond," by T. W. E. David, *The Mining Journal*, August 24th, 1907.

Digitized by Google

There may exist on one of these fields a mine; very few of the stones, however, would come from there; otherwise we would have found similar diamond-fields near, say, for instance, the Roberts Victor, or other mines lying in a flat country.

This theory. of course, is still absolutely hypothetical till we find a diamond embedded in undoubted diabasic rock; still, however, it may be of value, as much money has been spent on certain farms where diamonds were found spread all over the ground, suggesting the idea that they must have come from a pipe.

Following up this theory, we may expect occasionally to find diamonds in pyroxene rocks of any geological horizon, and the diamonds in the conglomerates of the Witwatersrand Beds of the Klerksdorp district may, for instance, have been derived from these diabasic rocks which are members of the Swaziland Series or the Fundamental Gneiss formation.

Digitized by Google

The Origin of River Diamonds within the Area of the Vaal (Read 14th October, 1907.)

By Hans Merensky.

INTRODUCTION.

It has been of great interest to me to gather from some short remarks made by Dr. Voit at the last meeting of this Society that he inclines to the belief that "the alluvial diamond deposits may have been derived from the decomposition of igneous sheets of kimberlite and consanguineous sheets of diabase of amygdaloidal character." Until then I was not aware of the researches of Dr. Voit or of any other one in this direction.

About eight months ago I had an opportunity of inspecting certain places on the Vaal River, in the neighbourhood of Windsorton and Barkly West. It was then that I arrived at the opinion that the origin of the river stones was not to be sought for in undiscovered occurrences of kimberlite, but in the diabasic rocks so widespread in that part of the country.

I then communicated this idea to certain friends, soliciting their co-operation towards a solution of the problem, and I intended to study the question more thoroughly on renewed and extended visits to the Vaal River diggings. Unfortunately I could never set aside the necessary time for the work, nor shall I be able to do so in the immediate future. I have, therefore, drawn up the following short statement of my observations and deductions, which I hope may induce others to make this interesting question a subject for additional field research.

THE CHARACTERISTICS OF RIVER DIAMONDS.

It is well known that diamond experts, buyers and valuators, can readily distinguish even small parcels of river stones from the diamonds coming out of fissures and pipes, which may for convenience be referred to as "kimberlite stones."

Digitized by Google

One might assume that this easy recognition is based on signs of transportation shown by the river stones; but all with any experience in handling these are well aware that such an assumption is erroneous. On repeated visits to the diamond buyers at Kimberley I have had the opportunity of convincing myself that only a minor portion of the stones—that is, those which had been found in the actual river beds—showed rounded edges and angles and a dull, clouded surface. The greater portion of them show hardly any traces of being worn, though the diamond, in spite of its great hardness, is readily affected by attrition when transported over even relatively short distances. The differences between a river and a kimberlite stone are not external, but are due to their respective intrinsic properties and character.

They represent, as stated, two entirely different kinds of stones. River stones possess a superior brilliancy, water, and hardness; if coloured, they are of well-pronounced deeper shades, and always retain the highest degree of translucency.[1] It is due to these properties that they command on an average a considerably higher price than kimberlite stones.

AREA OF DISTRIBUTION AND MANNER OF OCCURRENCE.

River stones occur approximately from somewhere south of Potchefstroom to the junction of the Vaal with the Orange River.

They occur in the Klerksdorp, Wolmaransstadt, Bloemhof, and Christiana districts in the Transvaal; also in the north-western districts of the Orange River Colony and in Griqualand, at Windsorton, Barkly West, etc., etc.

In small numbers, often as isolated stones, they are scattered over this enormous territory, which is about 300 miles in length, and extends in width to 50 miles and more.

Stones with signs of having been transported occur with sharp-edged ones; large and small stones are mixed together. At places they have undergone concentration through the influence of the Vaal River itself, in its present channel, and also on old river terraces; in its present and older tributaries.

They occur in a deposit of diabasic detritus. and are almost without exception associated with quartz in its many varieties, partly transparent and colourless, as rock-crystal, partly in its denser varieties, such as chalcedony, jasper, agate, etc.

Wherever such river stones have been discovered at a distance from the river, large sums of money have been spent from year to year on prospecting work under the impression and in the hope that pipes from which these valuable stones originated were awaiting discovery, but in every instance with the negative result that the primary origin of the river stones remains unknown to the present day. Just a few fissures and pipes were found which, without exception, proved to be unpayable on account of their low yield in diamonds, which are typical kimberlite

[1] This on the authority of W. J. R. Watson.

Digitized by Google

stones of mediocre quality. There is no doubt that some of these have been conveyed as alluvial diamonds into the river. These, however, have absolutely nothing in common with true river stones.

TOPOGRAPHY AND GEOLOGY OF THE COUNTRY WHERE RIVER STONES OCCUR.

The landscape over which these river diamonds are distributed is, as a rule, slightly undulating, with an occasional well-defined range of hills and isolated kopjes.

According to Messrs. Molengraaff, Hatch and Corstorphine, the geological formation consists, almost without exception, of diabasic rocks.[2] These rocks are generally placed with the Ventersdorp System; they are, therefore, considerably older than the Karroo formation, to which epoch all eruptions of kimberlite belong.

These diabasic rocks show now and then some resemblance to kimberlite, especially to undecomposed fissure rock, as I could observe, for instance, in the country south of Pniel.

EXPLANATION OF THE ABOVE-MENTIONED CONDITIONS.

It is impossible in view of the above that the river stones, with their peculiar properties, could have originated from the known kimberlite occurrences within the area of the diabase; it is equally unlikely that they came from other kimberlite deposits which have perhaps not yet been found, because it would be too great an improbability that such unknown occurrences should contain stones so entirely different from those found in all the known pipes and fissures.

The physical properties of river stones, so saliently different from all other diamonds, point, therefore, not to kimberlite, but to another matrix, "*Mattergestein*," and as such only the diabase deserves consideration, for the following reasons:—

Had these diamonds originated from another eruptive rock, for example granite, which perhaps might now be covered by younger formations, it would be more than remarkable had they been transported from their place of origin only into the area of the diabase, in which area they are associated almost exclusively with minerals derived from the decomposition of this rock. Again, such a transportation from various primary sites could not have failed to result in a natural concentration, inasmuch as the size of stones would decrease with the increasing distance of transport, and in an increasing intensity of wear. There is, however, no sign of such actions. Large-sized stones are found together with smaller ones, and the highest degree of attrition is shown on stones which occur alongside of others with sharp edges and angles.

Marks of having travelled are also frequently absent from the associated minerals.

---

[2] According to Molengraaff in the following varieties:—Amygdaloidal diabase, diabase, diabase porphyrite, quartz porphyry, felsitic amygdaloidal rocks, tufas and igneous breccias.

Digitized by Google

Of many interesting spots, one which I inspected between Fourteen Streams and the Frank Smith Mine showed on sloping ground genuine river diamonds amongst masses of amygdules, which, from their occurrence and appearance, could be only eluvial, and could not have been washed from any great distance.

I also examined several samples of so-called "diamondiferous gravel" received from a locality near Smit's Drift, and could detect no indications of advanced attrition.

Again, I was informed by diggers that diamonds were found on steep kopjes. Had these stones been left by an ancient river on such kopjes they would long ago have been swept down again whilst the river was cutting its bed to the present position. The only explanation, therefore, is that they must have weathered out from the decomposing diabase of the kopje, on which no evidence of the existence of any other rock was said to be found.

I am informed that these conditions are especially striking on the diggings of the Harts River; dry diggings were once confined to the dongas high above the water level of the river, where stones were found resting on diabase, the gravel in the river bed having proved to be too poor.

I have been assured that claims, situated far away from the river, after having been completely worked out, again yielded rich finds from the very same masses several decades later. Provided this be correct—and I am assured it was not due to less care in the previous sorting—there is only one explanation possible, that such stones must have been liberated from the decomposing diabase, exposed to more ready weathering in consequence of the previous handling.

Diggers prefer localities where below the gravel beds the underlying diabasic rocks are decomposed to some extent. They never omit to wash this mass together with the pay-gravel.

Not far from Vryburg a surface conglomerate which is said to contain river stones recently attracted renewed attention. I was told that one small stone was found still actually embedded in the calcareous cement.

The pebbles in samples I examined consist exclusively of diabase amygdules, which still show the original characteristic minute indentations. It is, therefore, probable that the diamonds also originated from diabase.

This Vryburg occurrence may also be evidence in support of my hypothesis, which I summarise briefly as follows:—

The Vaal River diamonds, which show marked differences from all kimberlite diamonds, originated from the diabasic rocks of the Vaal River or Ventersdorp System, probably from the more basic parts of the same, and not from undiscovered occurrences of kimberlite or from other eruptive rocks.

The diamonds found as eluvial stones together with other minerals weathered out from the diabase.

Through the action of the Vaal River and its tributaries, however, a partial concentration occurred, thus accounting for the richer alluvial patches and the rounded alluvial stones.

Digitized by Google

Other diamonds continue to weather out, and are added everywhere as eluvial stones, so that the effects of natural concentration, which ought to be observable otherwise, are again constantly obliterated, with the result that now large and small, sharp-edged and rolled, stones are found together.

I am prepared to admit that the foregoing deductions require some additional support and evidence. Certain facts may even appear strange, as, for instance, that no diamonds have been found, so far as I know, in the detritus of the Klipriversberg diabase, although this latter is closely correlated in age and general character with the Vaal River diabase.

It may be that not all varieties of diabase in the Ventersdorp System carry diamonds, but possibly only those which are specially rich in olivine. Certainty on this point can only be gained by future research and investigation.

I am not in a position to judge whether the diamonds on the Limpopo and in the Somabula Forest in Rhodesia, said to be like the Vaal River stones in character, can also be traced to an origin from similar diabasic rocks or not. Information on this point would prove of great interest.

Digitized by Google

Note on Lherzolite and Eclogite Boulders from the Roberts-Victor Mine (Read 12th August, 1907).

By J. P. Johnson.

In view of the valuable confirmation of the occurrence of diamonds in the eclogite boulders found in the South African diamond-bearing rock, brought forward at the last meeting of the Society by Dr. Corstorphine, the following notes on the lherzolite and eclogite boulders of the Roberts Victor Mine may be of interest.

The readily decomposable lherzolites, having suffered considerably from lying within the zone of oxidation, are barely recognisable. Prof. Young has described the microscopic characters of two thin sections from such boulders in the Transactions of the Society.[1]

Even the more resistant eclogites are as a rule much altered. The commonest form consists of brownish-red clouded garnets in an opaque dark green matrix. In some cases the garnets, and in others, the ground mass are dominant. Prof. Young has also described the microscopic characters of a thin section from one such boulder.[2]

Other varieties of eclogite—some exceedingly handsome—occur in this mine. The following are descriptions of some selected specimens in my collection:—

(a) Portion of a tabular banded boulder. The main mass consists of blue kyanite scattered throughout a light bluish-grey matrix. A band mainly of much clouded reddish-brown garnets forms the margin. A thin section under the microscope shows several grains of kyanite and one or two of garnet surrounded by large individuals of some mineral which has been altered to cryptocrystalline matter. In some cases these last contain fragments of the original mineral which in ordinary light is colourless and possesses brilliant polarisation colours (pyroxene?), while in others traces remain in the shape of faint cleavage lines. The kyanite, which is always twinned, shows characteristic cleavage and,

[1] Vol. ix., p. 121.
[2] *Op. cit.*

Digitized by Google

being apparently colourless, is not visibly pleochroic. The garnet shows characteristic cracks. Both the kyanite and garnet are surrounded by decomposition zones.

(b) Also portion of a banded tabular boulder. The main mass consists of colourless and pink garnets scattered throughout a holocrystalline matrix of semi-translucent grass-green diopside. The garnets are subordinate and elongated in the direction of banding. At the outside edge there is a margin about two centimetres thick where garnets predominate and vary from colourless to smoky grey and light brown. There is a string of ilmenite granules at the junction of this zone with the main mass. A thin section under the microscope shows in one case an interesting intergrowth of garnet with diopside, the garnet occurring as laths arranged along the cleavage planes of the pyroxene prism, but showing no other features of special interest.

(c) Blue kyanite and amber-coloured garnets scattered throughout a light grey matrix. Microscopically it consists of a holocrystalline aggregate of kyanite, garnet, and cryptocrystalline individuals. These last do not show any traces of the original mineral. The garnets in some cases enclose round grains of kyanite. The kyanite and garnet are surrounded by decomposition zones.

(d) A holocrystalline aggregate of red garnet and translucent dark green diopside. The latter traversed by a network of opaque decomposition lines. A thin section, under the microscope shows no special features.

These lherzolite and eclogite boulders contain in proportionate abundance all the characteristic minerals of the eruptive diamond-bearing breccia and the writer thinks there is no doubt that they are the more resistant portions of a rock which has gone to form the bulk of the breccia and which is the real home of the diamond.

This lherzolite-eclogite rock may exist either as a wide-spread consolidated formation occurring at great depths or as a deep-seated molten magma, portions of which have been forced into the lower part of the vent from time to time and consolidated there. The tabular shape and banded structure of so many of the eclogite boulders suggests that the former condition is the most likely, and it may be that in South Africa rock-folding has nowhere been severe enough to bring it within the reach of denudation and consequent exposure at the surface. In the few outcrops that we know elsewhere they are associated with extremely ancient rocks, but their exact relationship to them is obscure.

The view that they are not boulders but segregations from the matrix in which they are found, seems to me to present great difficulties. Passing over the opinion which I hold that the filling of the diamondiferous vents has yet to be proved an igneous rock—I can see nothing in it other than a purely fragmental formation—they may be enumerated as follows:—

(1) The boulders as seen *in situ* are sharply demarcated from the enclosing matrix. There is no passage from the one into the other as one expects to find in a magmatic segregation.

Digitized by Google

(2) When the same boulder is extracted it is seen to have a worn, polished and often striated exterior. The grains of garnet in the margin of the boulder are often worn down to half or more of their original diameter. Sometimes the boulders are deeply scored and grooved.

(3) Large isolated pieces of boulders are of not infrequent occurrence.

(4) Many of the boulders are more or less tabular, some are quite rectangular, the edges however being rounded, and most show a distinctly banded structure, the banding being always linear and never concentric. In some the banding is rendered very distinct by the arrangement of the different minerals in layers.

In short I regard the present shape of the boulders to be entirely due to attrition in the pipe, and can see no reason for supposing that their shape originated in a different way from that of the other boulders.

Digitized by Google

The Tin, Molybdenum and Lead Occurrences near Potgietersrust (Read 17th December, 1907).

By J. P. Johnson.

The Tin, Molybdenum and Lead occurrences herein described belong to that interesting type of metasomatic ore-body to which the term pneumatolytic has been applied. Though genetically the same, they each present a distinct facies. The country rock is granite.

TIN.

The Tin-deposits are situated in the mountainous country between the Magalakwin river and its tributary, the Sterk.

Running north and south through Groenfontein and extending into Roodepoort on the one hand and Sterkwater on the other, is a quartz-vein containing massive fluorite and a green substance together with much coarsely crystalline cassiterite. This vein has a dip of about 15 deg. to the west.

The granite adjoining this quartz-vein on the east is sparsely impregnated with small crystals of cassiterite for a width of about forty yards. Megascopically this impregnated granite shows little evidence of alteration. Apart from the cassiterite, specks of a yellow and green substance and an occasional crystal of violet fluorite, alone differentiate it from the adjoining rock. Fluorite occurs also on joint planes in this granite.

East of this belt of impregnated granite and arranged in a line roughly parallel to it, are small patches of similarly impregnated granite, and groups of peculiar cylindrical pipes. These extend into Zaaiplaats on the north and Solomon's Temple on the south.

The cylindrical pipes consist of a core of altered granite thickly studded with crystals of cassiterite, usually, but not always, surrounded by a sharply defined ring consisting of spherulites (about a centimetre in diameter) of black tourmaline closely packed in a white quartz matrix. Outside this is a halo of granite characterized by specks of some green substance which gradually merges into the unaltered rock.

Digitized by Google

The extent to which the granite is altered in these pipes is very variable in one and the same pipe. As a rule the greater part, of the rock still retains its granitic structure and to the naked eye seems to have suffered little alteration beyond the replacement of some of the constituents by the green substance, fluorite, and cassiterite. Much, in some cases the major portion, has, on the other hand, suffered such complete alteration as to be megascopically nothing more than a friable dirty green rock speckled with cassiterite. Between these two extremes every gradation can be observed.

The pipes are found to take an irregularly inclined course in depth and sometimes join together. They mostly dip to the west.

The occurrences on Sterkwater, Groenfontein, and Roodepoort are nearly all in fine-grained granite which has partly a granular and partly a graphic structure. Those on Zaaiplaats are mainly in coarse-grained granite. In texture the granite in the pipes is similar to that surrounding them.

Accessory materials occurring in the pipes are molybdenite, pyrite, chalcopyrite (and hence malachite), arsenopyrite and galenite. Grains of copper were also found in one of the pipes on Zaaiplaats embedded in the tourmaline spherulites at a depth of 130 feet.

It is to be hoped that the Mines Department will publish an accurate plan of this valuable and instructive occurrence.

Homologous copper-deposits are met with in the very same granite north of the village of Middelburg. They even include the peculiar cylindrical pipes. I have in mind an example in coarse-grained rock, which, there is reason to believe, is only one of a group. The copper-ore in it contains a notable percentage of silver and is associated with fluorite and the green substance.

Essentially similar copper-bearing pipes have recently been described from America.[1]

As will be seen from the appended microscopical notes the green substance referred to above is, mostly at least, some micaceous mineral.

MOLYBDENUM.

The Molybdenum-deposit on Appingadam is situated at the foot of the north end of the kopjes on the left bank of the Sterk river and occupies an irregularly shaped area.

The granite around this area is mainly coarse-grained and plentifully sprinkled with spherulites of tourmaline, though, so far as can be detected by the unaided eye, otherwise unaltered.

The granite within this area is also almost entirely of the coarse-grained type but shows additional alteration of varying intensity. The first manifestations are the increase in the number of tourmaline spherulites and the addition of the green (and yellow) substance and fluorite. Then molybdenite and cassiterite (which however is here rare) appear.

[1] *Trans. Amer. Inst. M.E.* (1907).

Digitized by Google

With the increase in quantity of these secondary minerals the granite gradually loses its original character. Finally in certain centres of intense alteration peculiar types of rock have been produced which bear no resemblance to the original. Their constituent minerals occur both in evenly granular aggregates and as irregular mixtures. They comprise tourmaline-quartz rock, mica-quartz[2] rock, mica-molybdenite rock,[2] molybdenite-arsenopyrite-quartz rock and arsenopyrite-fluorite rock. Sphalerite also occurs in irregular masses. These rock types of course pass one into the other and it is possible to get hand-specimens containing all the minerals mentioned together.

Molybdenite in the form of scales, often hexagonal, is the dominant metallic mineral. The yellow oxidation product, molybdite, also occurs.

An interesting feature of this altered area is the presence of groups of giant spherulites of tourmaline, some as much as four decimetres in diameter, in which the slender needles of the ordinary sized spherulite are replaced by stout columns. Tourmaline also occurs as short thick crystals associated with quartz in small irregular bodies.

LEAD.

The Lead-deposit is situated in a ridge which forms the boundary between Uitloop and Rietfontein.

The main occurrence is in a narrow but sharply defined zone of altered granite which strikes approximately north and south and dips at a big angle to the west. This is said to be traceable for a quarter of a mile.

The section is as follows :—

(a) Hanging Wall.

(b) *Mottled Red and Yellowish-green Rock.* Altered granite. Granitic structure mostly retained but partly obscure. 1 ft.

(c) *Bluish-white Chert-like Rock.* Traversed by a network of fluorite veinlets containing galenite. Altered granite. Traces of granitic structure retained in places. Specks of red feldspar throughout. 2 ft.

(d) Foot Wall.

A short distance to the west of this a similar occurrence runs parallel and has been exposed in a pit, but at the time of my visit had not been traced for any distance. It is not so sharply demarcated from the enclosing rock as in the main occurrence. It shows veinlets of chert and galenite-bearing fluorite traversing a narrow zone of the granite which is not megascopically much altered.

The country rock is a medium grained aggregate of white and red feldspar and quartz abundantly speckled with an obscurely defined black substance (mica).

---

[2] The mineral termed "mica" here is the green substance before referred to.

Digitized by Google

RELATION OF THE ORE TO THE GRANITE.

The Tin and Molybdenum occurrences are in the Newer (or Red) Granite.

The main mass of the Newer Granite is a coarse-grained aggregate of red orthoclase and quartz with very little mica, but patches of a fine-grained variety, which has sometimes a granular and sometimes a graphic structure, are not uncommon in it. As noted above, fine-grained granite is associated with the tin-bearing area, while a small body of it is present in the molybdenum-bearing area.

Fine-grained granite is also associated with the genetically similar tin-deposits at Enkeldoorn and Vlaklaagte which are also in the Newer Granite. Merensky[3] has noted that at the latter place it is intrusive, while Hall[4] has pointed out that at the former locality it passes gradually into the main mass of coarse-grained granite. The probable explanation of this at first sight contradictory evidence is that the fine-grained variety was injected into the coarse-grained rock before this last had completely solidified.

Merensky further expresses the opinion that the fine-grained granite is the ore-bringer. With this view however I must disagree. The fine-grained patches occur also in areas where there are no traces of the result of pneumatolitic action, while in the spots where this last has taken place it has affected both coarse and fine-grained rock indiscriminately.

I believe that these ore deposits were formed long after the solidification of both varieties of the Newer Granite, the agents operating through fissures and joint planes.

The Lead occurrence is in the Older (or Archaean) Granite. As will be seen from the appended microscopical notes, the ore-body is a line of crush in the granite, along which the galenite and associated secondary minerals have been deposited by solutions or vapours at the expense of the feldspars.

MICROSCOPIC CHARACTERS OF THE TIN-BEARING ROCK.

1. *Rock outside tourmaline-quartz ring.* This section shows much decomposed feldspar in graphic intergrowth with quartz, a grain of cassiterite and much green micaceous matter.

2. *Tourmaline-quartz ring.* Shows radiating bunches of tourmaline needles in a graphic intergrowth of quartz. Much of the quartz is undoubtedly secondary, being much clearer than the original and showing sharp crystal outlines. One of these crystals of secondary quartz contains a grain of cassiterite. There is also some green micaceous matter.

3. *Rock inside the tourmaline quartz ring.* This Section, which contains a quantity of cassiterite, is very feldspathic and contains comparatively little quartz. The feldspars are mostly decomposed but there

[3] H. Merensky, Zeitschrift für praktische Geologie, xii., p. 409 (1904).
[4] A. L. Hall, *Trans. Geo. Soc. S.A.*, viii., p. 52 (1905).

Digitized by Google

is a little plagioclase showing polysynthetic twinning. It also contains patches of green micaceous matter. There is also an interesting graphic intergrowth of cassiterite and feldspar in this section.

4. Resembles the last section but exhibits a more advanced stage of alteration. The feldspars are, except in places, almost entirely altered into the green micaceous matter, with which some chlorite is probably mixed.

5. Resembles the foregoing but there is even less feldspar left and the micaceous matter is in larger scales. Some opaque mineral which looks like specularite is also present.

6. This section is mainly composed of micaceous and calcareous matter with a little quartz, several crystals of pyrite and a single cassiterite grain.

7. This section is mainly composed of micaceous with some calcareous matter, a little secondary quartz, many tourmaline needles in clusters and some cassiterite.

8 and 9. Resemble Sections Nos. 3 and 4.

10. *Specimen from belt of impregnated granite.* This section shows a graphic intergrowth of quartz and feldspar, the latter being much decomposed and in some cases passing into the green micaceous matter. A few grains of cassiterite are present and are moulded, in some cases, by the feldspar prisms.

12. *Rock from Buffelskloof, west of Naboom Spruit Station.* This section shews specularite in a quartz veinlet in granite. The feldspars are much decomposed and partly replaced by the vein quartz.

13. *Specimen from Middelburg copper-bearing pipe.* This section is an aggregate of quartz and green micaceous matter.

MICROSCOPIC CHARACTERS OF THE LEAD-BEARING ROCK.

14. *Country rock.* A holocrystalline aggregate of microcline, orthoclase, plagioclase and quartz. Muscovite is also present together with chlorite which seems to be an alteration product of biotite.—Granite.

15. *Mottled red and yellowish green rock.* Much distorted, and even broken, microcline, orthoclase, plagioclase and quartz with some micaceous matter.—Crushed Granite.

16. *Bluish-white chert-like rock.* Resembles No. 14 but contains much secondary quartz and fluorite. In this section the quartz can be seen distinctly replacing plagioclase. Galenite is also present.

17. Resembles No. 16 but is mainly made up of secondary quartz and, to a less degree, of fluorite. The secondary quartz contains numerous plagioclase fragments. Microcline and orthoclase completely eliminated?

18. A fine-grained chert with comparatively large quartz grains here and there—Pneumatolitically altered Granite.

Digitized by Google

Digitized by Google

INDEX.

Page

Alteration of the Felspars in the Felspathic Quartzite underlying the Hospital Hill Slates, The. *R. B. Young* - - - - - - 62
Auriferous Conglomerates of the Witwatersrand, Notes on the - - 17
Ayrshire Mine, Lomagundi, Rhodesia, Note on the Gold-Bearing Rock of the - - - - - - - - - - - - - - 13

Beck, R. Note on the Cobalt Lodes of the Transvaal - - - 10
——— Note on the Gold-Bearing Rock of the Ayrshire Mine, Lomagundi, Rhodesia - - - - - - - - - - - - 13
Bonney, T. G. On the supposed Kimberlite Magma and Eclogite Concretions - - - - - - - - - - - - - 95
Bushveld Sandstone Series and the Overlying Volcanic Rocks, Note on the Correlation of the - - - - - - - - - 31

Cobalt Lodes of the Transvaal, Note on the - - - - - - - 10
Cobalt Lodes, Note on the Field Relations of the Transvaal - - - 36
Conglomerates of the Witwatersrand, Notes on the Auriferous - - 17
Corstorphine, Geo. S. The Occurrence in Kimberlite of Garnet-pyroxene Nodules carrying Diamonds - - - - - - - 65
Craighall, Petrological Notes on Rocks in the Vicinity of - - - 6

Diamonds, The Occurrence in Kimberlite of Garnet-pyroxene Nodules, carrying - - - - - - - - - - - - - - 65
——— The Origin of - - - - - - - - - - - - - 75
——— Within the Area of the Vaal, The Origin of River - - 107
——— Further Remarks on the Kimberlite Rock and the Origin of - 101

Eastern Rand, Petrographical Note on the Kimberley Slates in the - 1
Eclogite Boulders from the Roberts Victor Mine, Note on the Lherzolite and - - - - - - - - - - - - - 112
Eclogite Concretions, On the supposed Kimberlite Magma and - - 95

Felspathic Quartzite underlying the Hospital Hill Slates, The alteration of the Felspars in the - - - - - - - - - - 62
Further Remarks on the Kimberlite Rock and the Origin of Diamonds. *F. W. Voit* - - - - - - - - - - - - - 101

Garnet-pyroxene Nodules carrying Diamonds, The Occurrence in Kimberlite of - - - - - - - - - - - - - - 65
Geological Structure of the Middelberg District, with Special Reference to the Character, Relationships and Thickness of the Waterberg System, The. *E. T. Mellor* - - - - - - - 44
Gneiss Formation in Africa. *F. W. Voit* - - - - - - - 90
Granite North of Johannesburg, The Marginal Phenomena and Geological Relations of the - - - - - - - - - 51

Digitized by Google

Page

Henderson, J. McClelland. Petrographical Note on the Kimberley Slates in the Eastern Rand - - - - - - - - - - 1
Hospital Hill States, The Alteration of the Felspars in the Felspathic Quartzite underlying the - - - - - - - - - - - 62

Johnson, J. P. Note on Lherzolite and Eclogite Boulders from the Roberts-Victor Mine - - - - - - - - - - - 112
——— The Tin, Molybdenum and Lead Occurrences near Potgietersrust - - - - - - - - - - - - - - - 115

Kimberley Slates in the Eastern Rand, Petrographical Note on the - 1
Kimberlite, The Occurrence in, of Garnet-pyroxene Nodules carrying Diamonds - - - - - - - - - - - - - 65
——— Dykes and Pipes. *F. W. Voit* - - - - - - - - 69
——— Magma, Origin of the - - - - - - - - - 79
——— Magma and Eclogite Concretions, On the supposed - - 95
——— Rock and the Origin of Diamonds, Further Remarks on the - 101
Kynaston, H. Note on the Correlation of the Bushveld Sandstone Series and the Overlying Volcanic Rocks - - - - - - - 31
——— The Marginal Phenomena and Geological Relations of the Granite North of Johannesburg - - - - - - - - - 51

Lead Occurrences near Potgietersrust, The Tin, Molybdenum and - 115
Lherzolite and Eclogite Boulders from the Roberts Victor Mine - - 112
Lomagundi, Rhodesia, Note on the Gold-bearing Rock of the Ayrshire Mine - - - - - - - - - - - - - - 13

Marginal Phenomena and Geological Relations of the Granite North of Johannesburg, The. *H. Kynaston* - - - - - - - - 51
Mellor, E. T. Note on the Field Relations of the Transvaal Cobalt Lodes - - - - - - - - - - - - - - - 36
——— The Geological Structure of the Middelburg District, with Special Reference to the Character, Relationships and Thickness of The Waterberg System - - - - - - - - - - - 44
Merensky, H. The Origin of River Diamonds within the Area of the Vaal - - - - - - - - - - - - - - 107
Middelburg District, The Geological Structure of the, with Special Reference to the Character, Relationships and Thickness of the Waterberg System - - - - - - - - - - - - 44
Molybdenum and Lead Occurrences near Potgietersrust, The Tin - 115

Newcastle District, Natal, On a Collection of Permo-Carboniferous Plants from the - - - - - - - - - - - - 81
Notes on the Auriferous Conglomerates of the Witwatersrand. *R. B. Young* - - - - - - - - - - - - - - 17
Note on the Cobalt Lodes of the Transvaal. *Professor R. Beck* - - 10
Note on the Correlation of the Bushveld Sandstone Series and the Overlying Volcanic Rocks. *H. Kynaston* - - - - - - 31
Note on the Gold-bearing Rock of the Ayrshire Mine, Lomagundi, Rhodesia. *Professor R. Beck* - - - - - - - - - 13
Note on Lherzolite and Eclogite Boulders from the Roberts Victor Mine. *J. P. Johnson* - - - - - - - - - - - 112

Occurrence in Kimberlite of Garnet-pyroxene Nodules carrying Diamonds, The. *Geo. S. Corstorphine* - - - - - - - - 65
On a Collection of Permo-Carboniferous Plants from the St. Lucia (Somkele) Coalfield, Zululand, and from the Newcastle District, Natal. *A. C. Seward* - - - - - - - - - - - 81
On the supposed Kimberlite Magma and Eclogite Concretions. *T. G. Bonney* - - - - - - - - - - - - - - 95
Origin of Diamonds, The. *F. W. Voit* - - - - - - - - - 75
——— Further Remarks on the Kimberlite Rock and the - - - 101
Origin of River Diamonds within the Area of the Vaal, The. *H. Merensky* - - - - - - - - - - - - - - 107

Digitized by Google

Page

Permo-Carboniferous Plants from the St. Lucia (Somkele) Coalfield, Zululand, and from the Newcastle District, Natal, On a Collection of - - - - - - - - - - - - - - - 81
Petrographical Note on the Kimberley Slates in the Eastern Rand. *J. McClelland Henderson* - - - - - - - - - - 1
Petrological Notes on Rocks in the Vicinity of Craighall. *P. A. Wagner* - - - - - - - - - - - - - - 6

River Diamonds within the Area of the Vaal, The Origin of - - 107
Roberts Victor Mine, Note on the Lherzolite and Eclogite Boulders from the - - - - - - - - - - - - - - 112

Sandstone Series and the Overlying Volcanic Rocks, Note on the Correlation of the Bushveld - - - - - - - - - - - 31
Seward, A. C. On a Collection of Permo-Carboniferous Plants from the St. Lucia (Somkele) Coalfield, Zululand, and from the Newcastle District, Natal - - - - - - - - - - - - - - 81
St. Lucia (Somkele) Coalfield, Zululand, On a Collection of Permo-Carboniferous Plants from the - - - - - - - - 81

Tin, Molybdenum and Lead Occurrences near Potgietersrust, The. *J. P. Johnson* - - - - - - - - - - - - 115
Transvaal, Note on the Cobalt Lodes of the - - - - - - - 10
——— Cobalt Lodes, Note on the Field Relations of the - - 36

Voit, F. W. Kimberlite Dykes and Pipes - - - - - - - - 69
——— The Origin of Diamonds - - - - - - - - - 75
——— Gneiss Formation in Africa - - - - - - - - 90
——— Further Remarks on the Kimberlite Rock and the Origin of Diamonds - - - - - - - - - - - - - - - 101
Volcanic Rocks, Note on the Correlation of the Bushveld Sandstone Series and the Overlying - - - - - - - - - - - 31

Wagner, P. A. Petrological Notes on Rocks in the Vicinity of Craighall - - - - - - - - - - - - - - - 6
Waterberg System, The Geological Structure of the Middelburg District, with Special Reference to the Character, Relationships and Thickness of the - - - - - - - - - - - - 44
Witwatersrand, Notes on the Auriferous Conglomerates of the - - 17

Young, R. B. Notes on the Auriferous Conglomerates of the Witwatersrand - - - - - - - - - - - - - - 17
——— The Alteration of the Felspars in the Felspathic Quartzite underlying the Hospital Hill States - - - - - - - 62

Zululand, On a Collection of Permo-Carboniferous Plants from the St. Lucia (Somkele) Coalfield - - - - - - - - - - 81

Digitized by Google

Digitized by Google

Publications of the Geological Society of South Africa.

The under-mentioned publications can be purchased at the Office of the Society at the following prices:—

Annual Transactions	...	£2	0	0	to	£2	5	0
Quarterly Parts ...	...	...		...		0	15	0
Half-Yearly Parts ...	...	...		...		1	1	0
Monthly Parts (of certain old volumes)				...		0	2	6

There is a reduction of fifty per cent. on the above prices to Members.

OUT OF PRINT—Vols. I. and V.;
Vol. II.; Parts 1 and 2.

Anyone possessing these volumes and parts of volumes that are out of print, and wishing to dispose of them, should communicate with the Assistant Secretary.

The Transactions may be obtained from Messrs. Wm. Wesley & Son, 28, Essex Street, Strand, London, W.C., who are the Society's European Agents.

Digitized by Google

Digitized by Google

26,737

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY

OF SOUTH AFRICA.

CONTAINING THE MINUTES OF MEETINGS AND THE DISCUSSIONS ON PAPERS READ DURING 1907.

TO ACCOMPANY VOL. X. OF THE TRANSACTIONS.

EDITED BY THE HONORARY SECRETARY.

JOHANNESBURG:
Printed at The Transvaal Leader Office.
1908.

Digitized by Google

Digitized by Google

APR 27 1908

MINUTES OF PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY

OF SOUTH AFRICA.

1907.

Annual General Meeting, held in the Council Chamber, Chamber of Mines, Johannesburg, on Monday, 28th January, 1907, at 8 p.m., Dr. Geo. S. Corstorphine, President, in the Chair.

The President having announced that the necessary quorum was present, the Secretary read the notice convening the meeting, and the minutes of the Tenth Annual Meeting, held on 29th January, 1906, were read and confirmed.

The Annual Report was presented, and taken as read.

Annual Report of the Council for the Year ended 31st December, 1906.

MEMBERSHIP.

During the year under review 25 Members resigned, and 17 were removed from the list, in accordance with the rules of the Society.

The Council regrets to report the decease, during the past year, of Mr. David Don, a member of the Society.

The number of new Members elected who have qualified for Membership during the year is 47, and the total number of Members now stands at 281.

MONTHLY MEETINGS.

The Monthly Meetings of Members have been held in the Council Chamber, Chamber of Mines, and the thanks of the Society are due to the Executive of the Chamber for their kindness in allowing the use of this room.

Digitized by Google

CHANGES IN COUNCIL.

Since the last Annual Meeting two vacancies have occurred on the Council owing to the resignation of Messrs. F. H. Hatch and J. Kuntz, and the following were appointed to act in their stead, viz., Messrs. J. T. Carrick and C. Sandberg.

LIBRARY.

Bookcases have now been purchased and placed in the Museum, and the Honorary Librarian is at work arranging the Library so that the various volumes may be available for members of the Society.

The following donations and exchanges have been received for the Library during the past year :—

DONATIONS.

Presented by

BROWN, NICOL, and TURNBULL, C. C.
"A Century of Copper," by the donors.

CHAMBER OF MINES, TRANSVAAL.
Sixteenth Annual Report.

DE LAUNAY, L.
"L'Histoire de la Terre," by L. de Launay.

HENDRIKSEN, G.
"Sundry Geological Problems," by G. Hendriksen.

JONES, T. RUPERT.
"Caves and Cave Folk of Central France" (Reliq. Aquit.). "Reviews on Monograph of the Foraminifera and the Permo-Carboniferous Limestones of New South Wales, by F. Chapman and W. Hanchin," by T. Rupert Jones.

MOREAU, GEO.
"Étude sur l'État actuel des Mines du Transvaal," by Geo. Moreau.

PENCK, A.
"Climatic Features of the Pleistocene Age," and "Glacial Features of the Surface of the Alps," both by A. Penck.

RHODESIA CHAMBER OF MINES.
Reports of Executive, 1906, and Eleventh Annual Report, year ending 31st March, 1906.

SACCO, F.
"Resti Fossili di Rinoceronti dell' Astigiana"; "Les Lois Fondamentales de l'Orogénei de la Terre"; "Les Etages et les Faunes du Bassin Tertiaire du Piémont"; "Fenomeni di Corrugamento negli Schisti Crystallini delle Alpi"; "Sur la valeur Stratigraphique des Lepidocyclina et des Miogypsina," all by F. Sacco. Réunion Extraordinaire de la Société Géologique de France en Italie à Turin et à Gênes.

SAWYER, A. R.
"Petroleum Occurrences in the Orange River Colony," by A. R. Sawyer. "Discussion on Mr. A. R. Sawyer's Paper on "The Geology of Chunies Poort, Transvaal."

SCHÖNLAND, S.
Albany Museum Notes 22, "A Unique Stone Implement," by S. Schönland.

Digitized by Google

Presented by

TERMIER, PIERRE.
"Les Schistes Cristallins des Alpes Occidentales" ; "Les Nappes des Alpes Orientales et la Synthèse des Alpes," both by Pierre Termier.

TRANSVAAL UNIVERSITY COLLEGE.
Calendar for Year 1906.

TRUSTEES OF THE BRITISH MUSEUM.
Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt.

EXCHANGES.

America.

Received from

ACADEMIA MEXICANA.
Annales, vol. 1, parts 1 and 2.

GEOLOGICAL INSTITUTE OF MEXICO.
Transactions, vol. 1, part 10; Bulletin, Nos. 20 and 21.

MUSEO NACIONALE, BUENOS AIRES.
Annales del Museo Nacionale, serie iii., vol. 5.

MUSEO NACIONALE DE MONTEVIDEO.
Annales de Museo Nacional, tomo 2, part 1; series 2, parts 1 and 2.

SCIENTIFIC SOCIETY OF S. PAULO, BRAZIL.
Revista da Sociedade Scientifica de Sao Paulo, No. 2, Sept., 1905.

SOCIEDAD CIENTIFICA ANTONIO ALZATE, MEXICO.
Memoirs, vol. 13, Nos. 9 and 10; vol. 21, Nos. 1-12; vol. 22, Nos. 1-6; vol. 23, Nos. 1-4.

UNIVERSITAD DE LA HABANA.
Revista de la Facultad de Letras y Ciencias, vol. 1, No. 3; vol. 2, Nos. 1-3; vol. 3, Nos. 1 and 2.

ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA.
Proceedings, vols. 53-57, 1901-1905; vol. 58, part 1, 1906.

AMERICAN GEOGRAPHICAL SOCIETY.
Bulletin, vol. 37, No. 12, 1905; vol. 38, Nos. 1-10, 1906.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Bi-Monthly Bulletin, Nos. 7-12, 1906.

BROOKLYN INSTITUTE OF ARTS AND SCIENCES.
Cold Spring Harbor Monograph vi., "The Behavior of the Pond Snail"; The Museum of the Brooklyn Institute of Arts and Sciences Bulletin, vol. 1, No. 8.

FIELD MUSEUM OF NATURAL HISTORY.
Report Series, vol. 2, Nos. 5-7; and vol. 3, No. 2; Publications, Nos. 109 and 110.

GEOLOGICAL SURVEY OF NEW JERSEY.
Atlas, sheets 33 and 37; Topographical Maps, New Brunswick, Somerville, and Pluckemin Sheets, 1905 Edition; Annual Report of State Geologist for year 1905.

GEOLOGICAL SURVEY OF OHIO.
Bulletin Nos. 7 and 8, Series 4.

MARYLAND GEOLOGICAL SURVEY.
Annual Report of the State Geologist, vol. 5, 1905.

MICHIGAN ACADEMY OF SCIENCE.
Fifth and Seventh Annual Reports, 1903 and 1905.

Digitized by Google

Received from

MISSOURI BUREAU OF GEOLOGY AND MINES.
Vols. 1, 2, 3 and 4, 2nd series; Biennial Report of the State Geologist; Report of Committee to Visit and Examine the State Institutions of Missouri; Missouri Geological Survey, vol. 13, Preliminary Report, 1900.

MUSEUM OF COMPARATIVE ZOOLOGY AT HARVARD COLLEGE.
Bulletin, vol. 49 (Geol. Series, vol. 8, No. 4).

SMITHSONIAN INSTITUTE.
Annual Report, 1904; Sundry Papers on Geological and Hydrological subjects.

UNITED STATES GEOLOGICAL SURVEY.
Bulletin, Nos. 243, 257, 268 and 269; Water Supply Papers, Nos. 119-122, 124, 126, 128, 132, 153, 154, 157, 165-169, and 171; Professional Papers, Nos. 44, 45, 47-49; Monographs xlvii. and xlviii.; Atlas to accompany Monograph xxxii.; Mineral Resources, 1904.

UNITED STATES NATIONAL MUSEUM.
Bulletin, No. 55; and "Contribution to the History of American Geology, 1906," by E. P. Merrill.

UNIVERSITY OF CALIFORNIA.
Bulletin of the Department of Geology, vol. 4, Nos. 2-13; vol. 6, No. 3; vol. 7, No. 2; Register, 1904-5; Preliminary Reports of the State Earthquake Investigation Commission.

Asia.

GEOLOGICAL SURVEY OF INDIA.
Records, vol. 32, parts 3 and 4; vol. 33, parts 1, 2 and 4; vol. 34, part 2.

IMPERIAL UNIVERSITY, TOKIO, JAPAN.
Calendar, 1905-6; The Journal of the College of Science, vol. 21, articles 2 and 5.

Australia.

GEOLOGICAL SURVEY OF NEW SOUTH WALES.
Monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales.

GEOLOGICAL SURVEY OF VICTORIA.
Bulletin No. 18; Special Report, "The Economic Minerals and Rocks of Victoria," by A. E. Kitson, F.G.S.

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA.
Bulletin, Nos. 21-23; Annual Report, Geological Survey of Western Australia, 1905.

NEW ZEALAND GEOLOGICAL SURVEY.
Bulletin No. 1 (New Series).

NEW ZEALAND MINES DEPARTMENT.
Papers and Reports relating to Minerals and Mining, 1906.

Europe.

ROYAL ACADEMY OF SCIENCES, AMSTERDAM.
Bulletin, Dl. 12, No. 3, 1906; Proceedings, vol. 8, parts 1 and 2.

GEOLOGISTS' ASSOCIATION (LONDON).
Proceedings, vol. 19, parts 6-10; List of Members, February, 1906.

GEOLOGICAL SOCIETY OF BELGIUM.
Transactions, vol. 32, part 4; vol. 33, parts 1 and 2.

GEOLOGICAL, PALÆONTOLOGICAL AND HYDROLOGICAL SOCIETY OF BELGIUM.
Transactions, vol. 19, parts 3-5; vol. 20, parts 1 and 2.

Digitized by Google

Received from

CAMBRIDGE UNIVERSITY LIBRARY.
Report of the Library Syndicate for year ending 31st December, 1905.

GEOLOGICAL SURVEY OF ENGLAND AND WALES.
Memoirs, "Water Supply of Suffolk"; "The Geology of the Country near Sydmouth and Lyme Regis"; "Soils and Subsoils"; "Guide to the Geological Model of the Isle of Purbeck"; and "Water Supply of the East Riding of Yorkshire."

GEOLOGICAL SOCIETY OF LONDON.
Quarterly Journals, vol. 62, Nos. 245-248; Geological Literature for year ending 31st December, 1905; List of the Geological Society of London, 15th November, 1906.

INSTITUTE OF MINING AND METALLURGY.
Advance Proofs of Papers read at Meetings; Bulletin, Nos. 15-27; Transactions, vol. 15, 1905-6.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.
Transactions, vol. 55, part 5; vol. 56, parts 1-3; Annual Report of Council, 1904-5 and 1905-6; Report of Committee on Mechanical Coal Cutting, part 2.

ROYAL GEOGRAPHICAL SOCIETY.
Journal, vol. 27, Nos. 1-6; vol. 28, Nos. 1-6.

GEOLOGISKA COMMISSIONEN I FINLAND.
Bulletin, No. 16, 1905.

GEOLOGICAL SOCIETY OF FRANCE.
Bulletin, 4th Series, vol. 4, part 6.

K. K. GEOLOGISCHE REICHSANSTALT, WIEN.
Jahrbuch, vol. 55, parts 1 and 2; vol. 56, parts 1 and 2.

KÖNIGLICHE PREUSSISCHE GEOLOGISCHE LANDESANSTALT UND BERGAKADEMIE.
Jahrbuch, vol. 26, parts 1 and 3.

PETERMANN'S MITTEILUNGEN.
December, 1905, to November, 1906.

FONDATION DE P. TEYLER, HAARLEM, HOLLAND.
Archives du Musee Teyler, series 2, vol. 9, parts 3 and 4; and vol. 10, parts 1 and 2.

R. COMITATO GEOLOGICO D'ITALIA.
Bulletin, vol. 24, No. 2; vol. 25, Nos. 1 and 2.

GEOLOGICAL SOCIETY OF ITALY.
Bulletin, vol. 24, No. 2; vol. 25, Nos. 1 and 2.

REVISTA ITALIANA DI PALEONTOLOGIA.
Anno 10, No. 4; anno 12, Nos. 1-4.

TECHNICAL ACADEMY, DELFT, HOLLAND.
"Het onstaan en Verdwijnen van Waterstof en Methan onder den invloed van het organische Leven," by N. L. Söhngen; "Gescheidenis der Systematische Mineralogie."

Africa.

CHEMICAL, METALLURGICAL AND MINING SOCIETY OF S.A.
Journals, December, 1905, to November, 1906.

GEOLOGICAL COMMISSION OF THE CAPE OF GOOD HOPE.
Geological Map of the Colony of the Cape of Good Hope, sheet 1; Tenth Annual Report, 1905.

GEOLOGICAL SURVEY OF THE TRANSVAAL.
Memoirs Nos. 2 and 3.

Digitized by Google

Received from

GOVERNMENT MINING ENGINEER, TRANSVAAL.
Report for Half-years ending 30th June, 1905, and 31st December, 1905.

RHODESIA MUSEUM.
Fourth Annual Report, 1905.

RHODESIA SCIENTIFIC ASSOCIATION.
Proceedings, vol. 5, part 2.

SOUTH AFRICAN PHILOSOPHICAL SOCIETY.
Transactions, vol. 16, part 3.

SOUTH AFRICAN ASSOCIATION OF ENGINEERS.
Journals, 1906.

SURVEY DEPARTMENT OF EGYPT.
The Physiography of the River Nile and its Basin.

The Transactions of the Society are sent in return to the several Institutions mentioned above, and also to the following:—

The Albany Museum, Grahamstown.
The Bodleian Library, Oxford.
The California Academy of Sciences.
The Commissioner of Mines, Natal.
The Congressional Library, Washington, U.S.A.
The Geological Society of America, Cleveland, Ohio, U.S.A.
The Geological Survey of Natal and Zululand.
The Museo Michoachano, Morelia, Mexico.
The New York State Museum.
The Naturforschende Gesellschaft.
The State of Iowa Geological Survey, U.S.A.
The South African Museum, Capetown.
The Natural History Museum, South Kensington, London.
The Seymour Memorial Library, Johannesburg.
The University of London Library.
The University of Minnesota, U.S.A.

MUSEUM.

The Museum remains under the same control as last year.

Since its institution the Museum has been generously supported by the Chamber of Mines. During the past year, however, an arrangement has been made by which the necessary funds are supplied by the Johannesburg Museum Committee. The Council of the Geological Society has for some time past been desirous of seeing the present collections develop into a Municipal Museum worthy of the town, and the financial arrangement now prevailing is a step in the desired direction.

The Society has again to thank the Executive of the Chamber of Mines for a grant of £100 to cover expenses incurred during the year, and to assist towards the up-keep of the Museum and Library.

The following specimens have been presented to the Museum during the year:—

Presented by

BOWKER, M.
Syenite, Leeuwfontein; White Fluorspar, Pienaar's River; Epidote, Tweefontein; two Aphanitic Diabases, Edendale Lead Mines; seven Porphyrites, Pienaar's River.

Digitized by Google

Presented by

BURGESS, M.
Copper Ores from the Stratan Copper Co., Ltd., Crocodile River.

FRY, ELLERTON.
Fossils from Longlands, Kimberley.

HOLMES, G. G.
Stone Implements from Krugersdorp District.

HEANEY, MAJOR M.
Wulframite, Bulawayo, Rhodesia.

JARVIS, M.
Gypsum, Niagara Falls, U.S.A.; Copper Ore and Matte, Montana, U.S.A.; Copper Ore, Henley-on-Klip, Transvaal.

JOHNSON, J. P.
Twelve Specimens of the Saxon Dyke.

MOFFAT, H. W.
Calamine, Galena and Pyrites from Rhodesian Broken Hill; Cerussite, Hopeite, Blende and Galena, Chromate of Lead, Carbonate and Silicate of Zinc, Green Silicate of Zinc, Silicate of Zinc, all from Northern Rhodesia.

NATHAN, E.
Seven rock Specimens from the Grand Cañon, Arizona.

ROBINSON, W.
Tourmaline, North of Pietersburg; Sandstone and Porphyry, Queenstown; Diamond-bearing Deposit from Roberts Victor Diamond Mine.

ROOS, J. VON.
Forty-three Specimens, composed of—
Gneiss, two Calcite, Hornblende Schist, Quartz with Tourmaline, Tremolite, Breccia with visible Gold, Rosequartz from Madagascar.
Crystal of Beryl, and three Pyroxenites with visible Gold, from Ambositra, Madagascar.
Laterite, three Lavas, Vein Quartz, Vein Quartz with Tourmaline, from Amzirabe, Madagascar.
Four Gneissose Granites, two Gneissose Granites from contact with overlying Trachytes, Zeolites and Garnets, ten Lavas, three Fossil remains embedded in Lapilli, from an old lake bed, from Lake Intasy, Western Madagascar. Lavas covered by Corals from Majota, Mozambique. Serpentine and six Basaltic Rocks from Uganda. Two Obsidians and fifteen Igneous Rocks found near crater, from Naiwashia.

SCHULLER, H.
One Schist, one Amphibolite, and one Quartzite, from Quadro Consolidated, Limited, Barberton.

WELLS, WM.
Glossopteris Leaf, from Hlabisa Coal Fields, Zululand.

NEW PAPERS.

During the year under review the following papers have been read, besides those which come under the heading of "Discussions on Papers Read":—

Author.

ANDERSON, WM.
"On the Geology of the Bluff Bore, Durban, Natal."

Digitized by Google

Author.

GAU, W. J.
"Geological Notes on a Portion of the Bushveld in the neighbourhood of the junction of the Elands and Oliphants Rivers."

GUEST, I. A. M.
"Note on Some Stone Implements found near Klerksdorp."

HALL, A. L. and HUMPHREY, W. A.
"The Black Reef Series and Underlying Rocks in the neighbourhood of Kromdraai and Zwartkop, north of Krugersdorp."

HOLMES, G. G.
"The Geology of the South-Western Transvaal."

JOHNSON, J. P.
"The Main Reef Horizon on the Eastern Edge of the Witpoortje Break."
"The Geology of the Neighbourhood of the Roberts Victor Diamond Mine."

JOHNSON, J. P. and YOUNG, R. B.
"The Relation of the Ancient Deposits of the Vaal River to the Palæolithic Period of South Africa."
"Eoliths from Leijfontein, Herbert."

JORISSEN, E.
"Structural and Stratigraphical Notes on the Klerksdorp District, with special reference to the Unconformity beneath the Elsburg Series."

KYNASTON, H.
"The Geology of the Neighbourhood of Komati Poort."
"Note on the work of the Geological Survey of the Transvaal."

MELLOR, E. T.
"The Origin of 'Wash-outs' in Coal Mines, and their relations to other features of the Transvaal Coal Measures."
"The Position of the Transvaal Coal Measures in the Karroo Sequence."

MELLOR, E. T. and LESLIE, T. N.
"On a Fossil Forest recently exposed in the Bed of the Vaal River at Vereeniging."

ROGERS, A. W.
"The Campbell Rand and Griquatown Series in Hay."

SANDBERG, C.
"Tectonical Remarks on the probable big Tygerberg Inverted Fold, and on the relative position between the Witteberg Quartzites and the Dwyka and Ecca Series in the Prince Albert District of the Cape Colony."
"Notes on the Structural Geology of South Africa."

YOUNG, R. B.
"The Calcareous Rocks of Griqualand West."

YOUNG, R. B. and JOHNSON, J. P.
"Glacial Phenomena in Griqualand West."

DRAPER MEDAL.

The Draper Medal was not awarded during the past year, and remains open for competition till 31st March, 1907, under the same conditions—with the exception that the age limit has been extended to 35 years.

Digitized by Google

FINANCE.

As may be seen from the accompanying statement of accounts, the Society is in a satisfactory financial position.

The Council desires to express its appreciation of the services rendered during the past year by Mr. W. W. R. Jago as Assistant Secretary.

On behalf of the Society,

E. JORISSEN,
Hon. Secretary.

Johannesburg, 8th January, 1907.

Digitized by Google

GEOLOGICAL SOCIETY OF SOUTH AFRICA.

BALANCE SHEET at 31st December, 1906.

LIABILITIES.			ASSETS.	
To Subscriptions paid in advance		£ 29 5 6	By Museum (including sundry donations) Book Value	£250 0 0
,, Donations in respect of Museum Specimens, Library, etc., for which no liability exists ...		350 0 0	,, Library ... ... ,,	113 1 0
,, Revenue and Expenditure Account—			,, Transactions ... ... ,,	50 0 0
Balance at Credit of this Account at 31st December, 1905 ...	£ 84 18 11		,, Furniture	29 8 6
Add Revenue over Expenditure for year 1906, as per Revenue and Expenditure Account	104 13 4		,, Amount Deposited in Savings Bank (Transvaal), including interest to 30th June, 1906	21 9 2
		189 12 3	,, Sundry Debtors for arrear subscriptions, etc. ...	61 6 2
			,, Cash at Bankers	43 12 11
		£568 17 9		£568 17 9

I hereby certify that I have examined the Books, Bank Pass Book and Vouchers of the Geological Society of South Africa for the year ending 31st December, 1906, and I find the above statement to be a true extract therefrom.

JOHANNESBURG, 8th January, 1907.

CHAS. STUART, *Chartered Accountant, Honorary Auditor.*

REVENUE AND EXPENDITURE ACCOUNT for the Year ending 31st December, 1906.

EXPENDITURE.			REVENUE.	
To Charges		£ 1 1 6	By Subscriptions	£630 0 0
,, Insurance		6 15 0	,, Entrance Fees	50 8 0
,, General Expenses, including Postages		53 16 2	,, Sale of Transactions during the year	18 19 0
,, Advertising		5 0 0	,, Chamber of Mines of the Transvaal— Contribution to Society's Funds towards Museum Curator's Salary and Library	145 0 0
,, Rent and Lighting		17 1 0	,, Interest on Deposit in Savings Bank to 30th June, 1906	0 9 2
,, Salary of Assistant Secretary		120 0 0		
,, Printing and Stationery—				
General Printing and Stationery ...	£ 28 4 6			
Printing Transactions	408 4 8			
		436 9 2		
,, Museum Account— Museum Curator's Salary, Jan.-May, 1906 (5 months)		100 0 0		
,, Balance carried to Balance Sheet		104 13 4		
		£844 16 2		£844 16 2

Examined and found correct.

E. JORISSEN, *Hon. Sec. and Treas.*

JOHANNESBURG, 8th January, 1907.

CHAS. STUART, *Chartered Accountant, Honorary Auditor.*

Digitized by Google

GEOLOGICAL SOCIETY OF SOUTH AFRICA.

PAST PRESIDENTS.

(The names of those deceased are printed in *italics*).

1895-1902	*H. Exton.*
1903	G. A. F. Molengraaff.
1904	A. R. Sawyer.
1905	F. H. Hatch.

PAST SECRETARIES.

1895-1901	David Draper.
1902-1903	J. Dampier Green.
1903-1904	Geo. S. Corstorphine and F. H. Hatch.
1904	F. H. Hatch.
1905	Geo. S. Corstorphine.

LIST OF MEMBERS, 31st DECEMBER, 1906.

HONORARY MEMBERS.

Becker, Prof. G. F.	Geological Survey, Washington, U.S.A.
Bonney, Prof. T. G.	9, Scroop Terrace, Cambridge, England.
De Launay, Prof.	Ecole de Mines, Paris, France.
Draper, David...	Box 3517, Johannesburg.
Dunn, E. J.	Roseneath, Kew, Melbourne, Australia.
Jones, Prof. T. Rupert, F.R.S. ...	Penbryn, Chesham Bois, Chesham, England.
Molengraaff, Dr. G. A. F.	Hilversum, Holland.
Penck, Prof. A.	Georgenstrasse 34/36, Berlin W. 7, Germany.
Schenck, Professor A.	Schillerstrasse No. 7, Halle, Germany.
Schmeisser, Berghauptmann ...	Kgl. Oberbergamt Toschenstrasse No. 2, Breslau, Germany.
Seeley, Prof. H. G., F.R.S. ...	25, Palace Gardens Terrace, Kensington, London.
Seward, A. C., M.A., F.R.S. ...	Cambridge, England.

Digitized by Google

ORDINARY MEMBERS.

Aburrow, C.	Box 534, Johannesburg.
Acutt, Sidney	Barrett G.M. Co., Ltd., Godwan River Station, Transvaal.
Adler, Henry	Box 1059, Johannesburg.
Adler, H. W.	c/o Geldenhuis Deep, Ltd., Box 1056 Johannesburg.
Alexander, G.	Box 1842, Johannesburg.
Anderson, W.	Box 2825, Johannesburg.
Andrews, A. J.	Box 71, Germiston.
Armstrong, W. L.	Box 1542, Johannesburg.
Atkin, A. J. R.	Box 6231, Johannesburg
Auret, A. A.	Box 838, Johannesburg.
Baerecke, H.	Box 1164, Johannesburg.
Baerveldt, P. C.	Box 1005, Johannesburg.
Bagshaw, J. F.	Box 1127, Johannesburg.
Ballot, John	c/o Bank of Africa, Cannon Street, London.
Beadon, R. B.	Box 42, Randfontein.
Bell, W. Reid	Box 2263, Johannesburg.
Bernard, F.	New Gold Venture Synd., Gondplats, Schweizer Reinike, Transvaal.
Berrington, E. D.	Ayrshire Mine, Mashonaland.
Bleloch, R.	Box 738, Johannesburg.
Bleloch, W.	Box 738, Johannesburg.
Bottomley, H.	Box 355, Krugersdorp.
Bowker, J. Mitford	Box 1007, Johannesburg.
Bradford, Wager	Langlaagte Deep, Ltd., Box 1056, Johannesburg.
Brakhan, A.	Box 1156, Johannesburg.
Broad, C.	Box 3525, Johannesburg.
Broadbridge, Walter	Box 1279, Johannesburg.
Brodigan, C. B.	Box 3, Brakpan.
Brown, Nicol	4, The Grove, Highgate, London N.
Bucher, E. J.	Box 1767, Johannesburg.
Butler, R.	Box 357, Johannesburg.
Calderwood, J. M.	Box 2295, Johannesburg.
Campbell, C. E.	Douglas, Griqualand West, C.C.
Carrick, Jas. T.	Box 646, Johannesburg.
Carter, B. Palmer	Box 1021, Johannesburg.
Catlin, R. M.	133 Hope st., Providence, U.S.A.
Chairman of East London Public Library	Box 59, East London.
Chalmers, J. A.	Box 226, Bulawayo.
Chambers, A. L.	Messina (Transvaal) Dev. Co., Ltd., Grenfell Camp, via Louis Trichardt, Transvaal.
Chandler, W. M.	Box 405, Pretoria.
Chilton, J.	Box 4687, Johannesburg.
Chudleigh, S.	Box 743, Johannesburg.
Collings, B. I.	c/o Rand Club, Johannesburg.
Colquhoun, T. Grant...	Durban Navigation Collieries, Ltd., Dannhauser, Natal.
Conran, B.	London Stock Exchange, London.
Cooke, Capt. H. St. John	c/o Rand Club, Johannesburg.
Cooper-Key, A.	Box 1020, Johannesburg.
Copland, Maurice	Box 1030, Johannesburg.
Corstorphine, G. S.	Box 1167, Johannesburg.
Coster, Alfred	Surveyor-General's Office, Bloemfontein.

Digitized by Google

Cottrill, G. St. John	Box 4829, Johannesburg.
Coutts, Wm.	Box 4696, Johannesburg.
Cowan, B. W.	Box 93, Mafeking, Rhodesia.
Cree, G. I.	Box 149, Johannesburg.
Cresswell, F. H. P.	Box 4023, Johannesburg.
Crosby, A.	Douglas Colliery, Balmoral, Transvaal.
Cullinan, T. M.	Box 286, Johannesburg.
Danks, Andrew	Box 2701, Johannesburg.
Davis, F. H.	Box 1934, Johannesburg.
Davies, J. E. Mills	Box 1054, Johannesburg.
De Jager, H.	Box 3358, Johannesburg.
De Jongh, J. N.	Box 1030, Johannesburg.
De Lacey, E. D.	Box 81, Roodepoort.
Dennison, J.	c/o Anglo-French Expl. Co., Ltd., 208/24, Salisbury Hse., London E.C.
De Pencier, H. P.	Box 112, Roodepoort.
De Roos, A. J.	Box 1741, Johannesburg.
Dessauer, A. von	Box 2083, Johannesburg.
Diamond, F. W.	Box 360, Johannesburg.
Dickson, A.	Box 738, Johannesburg.
Distel, C.	Box 149, Johannesburg.
Dodd, Michael	Box 310, Johannesburg.
Dodds, J. W.	Box 34, Boksburg.
Dudgeon, W. F. H.	Gagar Bank, Corstorphine, Scotland.
Dunne, H. C.	Box 1557, Johannesburg.
Dunning, Sir Edwin...	Box 2567, Johannesburg.
Dunning, Frank	Knights Deep, Ltd., Box 143, Germiston.
Durham, Jas.	Box 2734, Johannesburg.
Du Toit, A. L.	S.A. Museum, Capetown.
Dyer, S. C.	Box 401, Johannesburg.
Eckstein, F.	Box 149, Johannesburg.
Elkan, M. G.	Box 277, Johannesburg.
Eloff, S. J. P.	c/o Trans. Univ. College, Box 1176, Johannesburg.
Emley, F.	Box 1603, Johannesburg.
Evans, T. H.	Ty. Rhôs., Fishguard, Pembrokeshire, England.
Evans, P. R.	Box 6034, Johannesburg.
Ferguson, Jas....	Box 1301, Johannesburg.
Frames, M. E....	Box 8, Johannesburg.
Frames, P. R....	Box 189, Johannesburg.
Francis, A. W.	Box 4706, Johannesburg.
Francke, M.	Box 1156, Johannesburg.
Frean, J. J.	Ventersdorp, Transvaal.
Gallwey, A. Payne	Box 138, Johannesburg.
Garbe, John	Brown's Buildings, Johannesburg.
Garrard, J. Jervis	Durban Club, Durban, Natal.
Gau, W. J.	Box 209, Johannesburg.
Gauf, J. L.	Box 949, Johannesburg.
Gibson, Jas.	298, Smith Street, Durban, Natal.
Glyn, C.	c/o Glen Deep, Ltd., Box 184, Germiston.
Goldman, A.	Box 4931, Johannesburg.
Goldring, A. R.	202/3, Salisbury House, London, E.C.

Digitized by Google

Government Librarian	Orange River Colony Government Library, Bloemfontein, O.R.C.
Gray, I. Thord	Box 5162, Johannesburg.
Greathead, Percy	Box 5036, Johannesburg.
Greathead, Walter H.	Box 4751, Johannesburg.
Green, J. Dampier	Box 340, Johannesburg.
Gregory, J. W.	Glasgow University, Glasgow, Scotland
Griffiths, Harry D.	Box 2146, Johannesburg.
Gubbins, J. G.	Ottoshoop, Zeerust District.
Guest, Ivor A. M.	c/o Box 1, Klerksdorp.
Hall, A. L.	Box 387, Pretoria.
Hamilton, C. J.	Box 678, Johannesburg.
Hamilton, W. Laurie	Box 678, Johannesburg.
Hanau, Carl	Box 433, Johannesburg.
Harger, H. S.	Box 1945, Johannesburg.
Harries, W. M.	Box 1167, Johannesburg.
Hatch, F. H.	c/o Messrs. Lewis & Marks, Threadneedle House, 28-31 Bishopsgate St. (Within), London.
Hay, Errol	Box 231, Johannesburg.
Hayllar, H. F.	Box 647, Johannesburg.
Hedges, J. S.	Commissioner of Mines' Office, Pietermaritzburg, Natal.
Hellmann, F.	East Rand Proprietary Mines, Ltd., Post Office, East Rand.
Henderson, J. A. Leo	120 Bishopsgate St. (Within), London, E.C.
Henderson, J. McC.	Box 1146, Johannesburg.
Heneage, E.	Audrey House, Ely Place, London.
Heslop, W. T.	St. George's Coal and Estate Co., Ltd., Hatting Spruit, Natal.
Hewitt, R. L.	Box 192, Germiston.
Heymann, R.	Box 2425, Johannesburg.
Hodge, A. P. D.	Box 146, Barberton.
Hoffman, J. I.	Box 4586, Johannesburg.
Hoffmann, G. J.	Box 1961, Johannesburg.
Holford, W. G.	National Bank Buildings, Simmonds Street, Johannesburg.
Holmes, G. G.	Box 5315, Johannesburg.
Honnold, W. L.	Box 2269, Johannesburg.
Horwood, C. Baring	c/o Rand Club, Johannesburg.
Hubbert, H. G.	Box 3700, Johannesburg.
Humphrey, W. A.	Geological Survey, Box 387, Pretoria.
Jameson, H. W. P. L.	Transvaal Technical Institute, Box 1176, Johannesburg.
Jeffreys, W. H.	Box 1031, Johannesburg.
Jennings, Hennen	Barney House, 1626, Rhode Island Avenue, Washington, D.C., U.S.A.
Johns, J. Harry	Box 231, Johannesburg.
Johnson, J. P.	Box 6231, Johannesburg.
Johnson, H. Luttman	Box 1167, Johannesburg.
Jones, C. K. Digby	Jumbo Gold Mine, Mazoe, Salisbury, Rhodesia.
Jones, H. E.	The Lodge, Culmington Road, Ealing, London.
Jorissen, E. J. P.	Box 305, Johannesburg.

Digitized by Google

Karlsen, A.	c/o Pretoria Club, Pretoria.
Kerr, R. England	Box 2909, Johannesburg.
Kingston, C. B.	Box 1030, Johannesburg.
Kleinenberg, T.	Box 40, Pietersburg, Transvaal.
Knecht, C. E....	Box 2269, Johannesburg.
Kopelowitz, B.	Box 47, Germiston.
Kotze, R. N.	Box 550, Johannesburg.
Krause, H. L.	Box 115, Roodepoort.
Kynaston, H.	Geological Survey Office, Pretoria.
Lacey, Wm.	Box 39, Maraisburg
Lambert, A. G.	c/o Rand Club, Johannesburg.
Lavenstein, L. H.	Box 4480, Johannesburg.
Lawn, J. G.	Box 231, Johannesburg.
Lecturer in Geology	Grey College, Bloemfontein, O.R.C.
Leng, R. W.	Box 4687, Johannesburg.
Leslie, C. D.	Box 192, Germiston
Leslie, T. N.	Box 23, Vereeniging.
Lindhorst, H.	Box 137, Johannesburg.
Long, E. C.	Principal Medical Officer, Maseru, Basutoland.
Lorentz, H.	Box 55, Johannesburg.
Loxton, J. C.	Box 3517, Johannesburg.
Macco, A.	Kgl. Berginspector, Stassfurt, Germany.
Macfarlane, T. J. M.	Box 1198, Johannesburg.
Maclatchy, A. G.	Gen. Manager, Trans. Cons. Coal Mines, Ltd., Belfast, Transvaal.
Marks, S.	Box 1030, Johannesburg.
Marriott, H. F.	1, London Wall Buildings, London.
Mayer, Richard	50, Holborn Viaduct, London, E.C.
McCarthy, E. T.	10 & 11, Austin Friars, London, E.C.
McCowat, R. L.	Box 318, Johannesburg.
McNellan, J. E.	Box 4998, Johannesburg.
Meister, E.	Box 2086, Johannesburg.
Mellor, E. T.	Geological Survey Office, Pretoria.
Melvill, E. H. V.	Box 719, Johannesburg.
Mennell, F. P.	Box 240, Bulawayo, Rhodesia.
Merensky, H.	Box 392, Johannesburg.
Meyer, Ed. C. J.	Box 262, Johannesburg.
*Miers, H.	Magdalen College, Oxford, *via* London.
Miller, A. M.	c/o Swaziland Corporation, Ltd., Embabane, Swaziland.
Milligan, J. T.	Box 321, Pretoria.
Morris, J.	East Rand Proprietary Mines, Ltd., P.O., East Rand.
Nash, W. B.	Box 5423, Johannesburg.
Newball, P. M.	Box 485, Johannesburg.
Nicolaus, R. C.	Box 3443, Johannesburg.
Niven, A. Mackie	Box 2365, Johannesburg.
Norman, L. R.	c/o New Club, Johannesburg.

* Life Member.

Digitized by Google

Oates, J.	Box 15, Langlaagte.
Oliver, W. H.	10 Avondale Road, Truro, Cornwall, England.
Orr, John	Box 3572, Johannesburg.
Osborn, P. B.	Box 4181, Johannesburg.
Pattrick, C. B.	Box 39, Springs.
Park, Mungo	Box 3, Brakpan.
Parkes, T. E.	Box 4580, Johannesburg.
Parrott, T. S.	173, Exploration Buildings, Johannesburg.
Payne, A. E.	Box 193, Germiston.
Payne, H. G.	Box 1279, Johannesburg.
Peirson, J. Waldie	Box 561, Johannesburg.
Phillips, Lionel	Box 149, Johannesburg.
Piercy, Scott S.	Box 2551, Johannesburg.
Pitt, R. G. Campbell	Box 5400, Johannesburg.
Pope, W. T.	Box 2448, Johannesburg.
Popham, J. L.	Box 669, Bulawayo, Rhodesia.
Pott, Wm.	Box 1146, Johannesburg.
Power, H. A.	Box 6364, Johannesburg.
Prister, A.	Box 3697, Johannesburg.
Raffalovich, W.	Box 6384, Johannesburg.
Recknagel, R.	Box 765, Johannesburg.
Reid, J.	Box 802, Johannesburg.
Rissik, C.	Box 401, Johannesburg.
Rissik, Johan	c/o Pretoria Club, Pretoria.
Ritso, B. W.	Public Works Department, Cradock, C.C.
Robellaz, F.	45 Rue Pomereu, Paris, France.
Robinson, R. W.	Coronation Synd., Ltd., Edenkop, Vlakfontein.
Rogers, A. W.	South African Museum, Capetown.
Ronaldson, J. H.	Box 5224, Johannesburg.
Rouillard, R. A.	Box 149, Johannesburg.
Rouliot, G.	Box 149, Johannesburg.
Rowe, Leo.	The Free State Mine, Leydsdorp,
Ruhs, C. A.	Box 38, Pietersburg, Transvaal.
Ryan, S.	P.O. Embabane, Swaziland.
Sandberg, C.	21 Robinson Blgs., Commissioner St., Johannesburg.
Sawyer, A. R.	Box 2202, Johannesburg.
Schlesinger, B.	Box 5997, Johannesburg.
Schoch, E. R.	Box 6254, Johannesburg.
Schulz, Aurel	Stamford Hill, Durban, Natal.
Schwarz, E. H. L.	Rhodes University College, Grahamstown, C.C.
Shanks, W.	Box 357, Johannesburg.
Sharwood, A. J.	Box 1242, Johannesburg.
Shepherd, Percy G.	Box 646, Johannesburg.
Simon, F.	Box 2, Springs
Simpson, Dundas	Box 1028, Johannesburg.
Simson, Leslie	Box 1167, Johannesburg.
Sjörgren, Hj.	Natural History Museum, Academy of Science, Stockholm, Sweden.

Digitized by Google

Sleeman, F.	Inhambane, Portuguese East Africa.
Smith, W.	Box 653, Johannesburg.
Soar, E.	Vereeniging Estates, Ltd., Vereeniging.
Stark, H. S.	Box 1081, Johannesburg.
Steart, F. A.	Geological Survey, Box 387, Pretoria.
Stokes, R. S. G.	Box 3996, Johannesburg.
Stollreither, A.	Box 41. Springs.
Stollreither, G. D.	Box 1156, Johannesburg.
Strange, H. F.	Box 2527, Johannesburg.
Struben, A.	Box 1228, Pretoria.
Stubbs, J. W. H.	Randfontein Est., Ltd., P.O. Randfontein.
Sutton, L. B.	Box 57, East Rand.
Tainton, C. F.	Box 97, Johannesburg.
Terwogt, P. C. E. Meerum ...	cor. Park and Melville Sts., Belgravia. Johannesburg.
Theron, Thos.	Box 147, Pretoria.
Thomas, J. F.	Box 16, Knights.
Thorburn, J. A.	18, Pretoria Street, Troyeville, Johannesburg.
Tracey, P. W.	Box 838, Johannesburg.
Trevor, T. G.	Inspector of Mines Office, Barberton.
Tucker, W. K.	Box 9, Johannesburg.
Tweddill, S. M.	Box 677, Pretoria.
Unger, F. A.	Robinson G.M.Co., Ltd., Box 1024, Johannesburg.
Valentine, E. J.	Box 1030, Johannesburg.
Visser, W. H.	Box 231, Johannesburg.
Voit, F. W.	Box 3781, Johannesburg.
Voskule, G. A.	Box 550, Johannesburg.
Wagner, P. A.	Box 543, Johannesburg.
Watts, J. Whitborne	Box 179, Barberton.
Webb, A. L.	Box 1124, Johannesburg.
Weber, Max	Box 1263, Johannesburg.
Weil, S.	Box 5499, Johannesburg.
Weldon, H.	Winchester House, Johannesburg.
Wells, Wm.	Box 22, Christiana, Transvaal.
Wens, Ernst	Hauptstoellerstrasse, 106², Stuttgart, Germany.
Wessels, J. J.	Knight's Deep Mine, Box 143, Germiston.
Wheler, A.	Box 292, Johannesburg.
White, Franklin	Box 669, Bulawayo.
White, W. L.	Witwatersrand G.M.C., Ltd., Box 1, Knights.
Wilkinson, D.	Box 485, Johannesburg.
Williams, Ernest	Box 965, Johannesburg.
Williams, Evan	Brakpan Collieries, Ltd., P.O., Brakpan.
Wilson, A. D.	Box 3358. Johannesburg.

Digitized by Google

Yates, John	Transvaal University College, Box 1176, Johannesburg.
Yeatman, Pope	Room 2007, 71, Broadway, New York, U.S.A.
Young, R. B.	Transvaal University College, Box 1176, Johannesburg.
Zimmermann, J.	Box 1156, Johannesburg.

Dr. Geo. S. Corstorphine in formally moving the adoption of the Report and Accounts, said:—

In presenting the Report, which has been already circulated, I may refer to some matters of interest.

The membership of the Society shows a slight advance on that of last year, and our financial position is also somewhat improved. The Council has to record some difficulty in the matter of arrear subscriptions, and I hope that those still outstanding will soon be paid. The Society spends practically all its money on the Transactions, and it is essential that many of the papers should be illustrated by maps and plates, which add considerably to our annual printing bill.

The Museum is under the same joint control as in 1905. During the earlier part of the past year the funds for the Museum were still provided by the Chamber of Mines, but in July an arrangement was made between the Johannesburg General Museum Committee and the Town Council by which the latter provided the money necessary for the curator's salary. The Chamber of Mines also gave a special grant of £100 towards the Society's funds for Museum purposes during the past year. We may hope that the ensuing year will see some steps taken towards the development of the present Museum into one worthy of this town, and I am sure that we may count on the support of both the Town Council and the Chamber of Mines.

Thanks to the above-mentioned grant from the Chamber of Mines, the Council was able to purchase cases in which to arrange the Society's Library, which is increasing at a rapid rate. We have exchanges with a large number of the Geological Societies and Surveys throughout the world, and the Honorary Librarian, Professor R. B. Young, is now at work making the books available for consultation by Members of the Society.

Since our last Annual Meeting, my predecessor in this chair, Dr. F. H. Hatch, has left South Africa. As Secretary and as President, Dr. Hatch worked arduously and whole-heartedly in the interests of the Society, and the Transactions bear witness to his activity in the field. Mr. J. Kuntz, a very old member, and an active contributor to the Transactions, also left us early in 1906. At the end of the year, Mr. J. G. Lawn, another Member of Council, who took a helpful part in the work of the Society, left Johannesburg to make his home in England.

Digitized by Google

It is natural in a community like this that from year to year we should be subject to considerable change in our membership, and we do not know what accession of strength may be before us, but we cannot hope easily to find substitutes for three such Members of Council as those whose absence we regret to-night.

The Transactions continue to maintain the standard of past years, and it is gratifying to know that geologists in England and elsewhere recognise the value of our publications. We are continually receiving applications from other societies to be placed on our exchange list.

Geological investigation under Government auspices continues to advance in Cape Colony and the Transvaal, and the work being done by the Directors of the two surveys and their respective staffs deserves our warm congratulation. It is, however, a matter of regret, to which this Society cannot give too strong an expression, that the enlightened and progressive Colony of Natal has suspended its geological survey. It is an unfortunate result of that depression from which all South Africa is suffering, but it is to be hoped that no long period will elapse till the survey is again begun. Natal cannot afford to suspend her geological stock-taking, nor should she fail to play her part in unravelling the interesting record which geology presents in this part of the world.

The Council has to record its indebtedness to Mr. Charles Stuart for his kindness in again acting as Honorary Auditor, and to Mr. W. W. R. Jago, the Assistant Secretary, for the able manner in which he has conducted the Society's affairs during the past year.

I have finally to express the Council's thanks for all donations to the Museum and Library during the past year.

I beg to move the adoption of the Report and Balance Sheet.

Mr. W. Reid Bell seconded the motion, which was put to the meeting and carried unanimously.

Anniversary Address by the President

(Dr. Geo. S. Corstorphine.)

THE GEOLOGICAL ASPECTS OF SOUTH AFRICAN SCENERY.

The relationship between the scenery and the geological phenomena prevailing throughout South Africa is a subject which affords scope for much fascinating study, and it will be my endeavour to-night to try to lay before you some of the more outstanding features, though this aspect of South African geology, like many others, cannot be dealt with exhaustively. Still, in travelling about the country, one has opportunity for comparing and contrasting the effects produced in the landscape by the same or different geological structures and formations, and no more attractive means can be found of relieving the tedium we all at times endure in journeying across the veld. No country affords

Digitized by Google

readier facility for the observation of the geological causes of scenery, though we may regret the fact that the facility owes its existence largely to the deplorable destruction of a former vegetation.

South African scenery is striking in its very monotony. Over hundreds, or rather thousands, of square miles there is a sameness which becomes oppressive, and a want of variety of feature which exceeds all imagining. There is nothing stimulating in the landscape but its immensity, yet, owing to the limited horizon, that immensity is not a characteristic immediately appreciated. The fascination of the veld is subtle and elusive, probably because, more there than anywhere else, is the charm due to conditions of sunshine and atmosphere, factors as essential to the final effect of a landscape as the configuration of the earth's surface.

The geological constitution and structure are the fundamental conditions on which the scenery of a country depends, and the resulting landscape is the outcome of the work done by the agents of denudation, which are themselves mainly due to the prevailing climatic conditions. Denudation working on the original structure, finding out the weak spots and gradually carving away even the hardest rocks, is the great factor in the evolution of a landscape. Whether that denudation is of one type or another, whether its weapons are rain, running water, snow and ice, or whether extremes of temperature aided by torrential tropical rains are the main modifying influences, depends on the climatic conditions. Similar geological conditions in regions enjoying different climates are subjected to different denuding forces, with the result that varied types of scenery are produced.

In a region such as South Africa, where the same geological formations extend from the Atlantic to the Indian Ocean, and from Agulhas to the retreating boundary of "Darkest Africa," the resemblances in the scenery are produced by the prevailing geological uniformity, and the differences are due to the variations in the climate.

It is to the action of long continued sub-aerial denudation that South African scenery owes most of its characteristic features. Geological investigation reveals the fact that long ages have elapsed since the main geological structures originated, and that even the present land surface has an antiquity for which any possible equivalent in years would convey no meaning to the human understanding, for since the upper beds of the Karroo System were deposited only a small portion of the coastal region has undergone submergence.

The present surface, here as elsewhere, is the last expression of the inter-action of various geological forces, some of which are as active to-day as they probably ever were, while others have in these days no share in the sculpturing of this landscape. Changes of temperature, wind and rain, surface and underground water, are probably not much less active in South Africa to-day than in past ages; whereas extreme glacial conditions have played no part in modifying the surface since the beginning of the Karroo Age, nor have volcanic agencies been at work since the eruption of the rocks of the Drakensbergen and the Lebombo Range.

Digitized by Google

The record of the South African strata tells us that before the present conditions began there were five periods during which a land surface existed. The earliest of these, and yet not the first, was formed by the complex mass of old rocks, now largely metamorphic in character, which we group together as the Swaziland System. To-day again these rocks play a large part in the constitution of the region, but whether any portion has remained continuously a land area cannot be determined. Certainly, the northern granite and schist regions were dry land while the central and southern areas were gradually covered by the sea in which the Witwatersrand Beds were laid down. These beds in turn were added to the land surface, and in the process of upheaval they underwent considerable folding and contortion. Having been again submerged, portions of the granite area, and probably the whole Witwatersrand System, formed the floor for the heterogeneous Ventersdorp System, with its succession of sediments and volcanic rocks, which in turn formed the third land surface that plays a part in the present one. When the next submergence ensued, the Black Reef, the Dolomite and the Pretoria Series were deposited in the northern areas, which we know as the Transvaal, Bechuanaland and Northern Cape Colony, though whether land conditions prevailed southward, or whether these beds were also deposited there, but were subsequently denuded, is again a matter of conjecture. At any rate, the evidence now available points to little deposition having occurred in the south during that period.

In the land surface next formed, the Swaziland, the Witwatersrand, the Ventersdorp and the Potchefstroom or Transvaal Systems all played some part, there being a gradual increase in complexity from the north southward.

During the next submergence there was deposited the Cape System, consisting of the Table Mountain, the Bokkeveld and the Witteberg Series, so predominant throughout western and southern Cape Colony, but represented in Natal by the Table Mountain Series only, and in the Transvaal most probably by the Waterberg sandstones and conglomerates.

When this period of deposition ended, the present terrestrial conditions began to prevail, for the characteristic Karroo System was not due to marine action, but, as is universally recognised, was formed mainly on the floor of an inland lake, while in the north land ice caused the extensive morainic deposit of the Ecca Glacial Conglomerate. This inland lake must have covered the greater portion of the region, and its shores certainly extended considerably south of the Karroo, for we find its deposits in the Breede River Valley, south of the Langebergen. It seems likely that the lacustrine conditions prevailed longest in the east, north-east, and north, for it is only there that the Stormberg Beds, the youngest division of the Karroo System, are found, and we have no reason to believe that their absence in the south and west is due to denudation.

The disappearance of the Karroo Lake was probably accompanied by, if not actually due to, the upheaval of the only true mountain chains which characterise South African scenery, and it was doubtless during the same period of disturbance that the enormous volcanic

Digitized by Google

activity now represented by the lavas of the Drakensbergen had its origin. The fossil evidence shows that this final upheaval most probably occurred in Jurassic times.

The submergences which occurred later affected only the coastal belt of the country, and are represented by the relatively small patches of Cretaceous rocks occurring in Cape Colony, Natal and Zululand, and the strip of Tertiary beds on the coast of the last-named province. Throughout the greater extent of Secondary and Tertiary times, the larger part of South Africa has been a land surface, and it is no wonder that its landscape should, to such an extent, show features due to denudation.

The present scenery has originated from the accretion of remnants of successive formations, each to a large extent formed by the disintegration of such portions of its predecessors as could be affected by the complex agents of denudation, while the sum total as presented by the land of to-day is undergoing continuous modification by the denuding agents now at work.

For the present purpose South Africa may be regarded as falling into three zones—the Coastal Zone, the Mountain Belt and the Interior Plateau.

The Mountain Belt.—The Mountain Belt is well developed in the west and south, and, as it is the essential feature in the structure of South Africa, I shall deal with it first. It embraces all the mountains which trend north and south on the western border of the Karroo, and the various ranges which run east from Hex River Pass to the vicinity of Algoa Bay. This extended area consists of a series of true mountain chains, showing as much intricacy of structure as the Alps of Central Europe. The most conspicuous geological component is the Table Mountain Series, but the two higher members of the Cape System also play a part, while on the internal boundary of this zone the lower beds of the Karroo System are included in the mountain folds. Sections showing true mountain structure are to be seen in such places as Mitchell's Pass, Hex River Pass, and in the various passes and river gorges which cut the mountain chains from north to south, such as the Montagu and Prince Alfred's Pass over the Langebergen and the Gamka River Poort and the Zwartberg Pass through the Zwartebergen. Mountain scenery of the wildest and grandest type is to be seen among the Zwartebergen, the Langebergen and the intervening ranges. Denudation has played a large part in the production of the present scenery, for the summits of all these ranges consist of Table Mountain quartzites, the geologically higher Bokkeveld Beds being confined to the flanks of the mountain chains, or even to the valleys, while the more quartzitic Witteberg Beds may form subsidiary ridges. On the south-western coast of Cape Colony, and at intervals eastward to Algoa Bay, the mountain belt virtually reaches the coast: the Cape Peninsula itself is an outlying remnant, having been cut off by denudation from the hills on the western shores of False Bay.

The South Africa of to-day has lost a considerable portion of the

Digitized by Google

mountain belt beneath the waves of the Indian Ocean, for from Algoa Bay northward through Natal we have no longer the same marked mountain scenery. Where the Table Mountain Beds appear in Natal they are lying for the most part horizontally, and though they form what are locally termed mountains, these, like the Cape Peninsula, are on the outskirts of the region of extreme pressure, which in eastern South Africa probably lies beneath the ocean.

Between such portions of the mountain belt as still exist in Natal and the more typical Langebergen and Zwartebergen of Cape Colony the contrast is very marked. In Natal the valleys are not structural valleys, but have been produced by the cutting out of great masses of the strata. The mountain tops are plateaux, formed of horizontal beds, whose edges form the sides of the deep-cut valleys.

The mountain belt being composed essentially of quartzites, those portions of it in the more arid districts of Cape Colony yield a very stern, bare landscape. In the east of Cape Colony and in Natal, however, the moister climate renders vegetation abundant, and we find the rocks of the mountain belt covered by bush, and even forest.

The Coastal Zone.—The Coastal Zone varies considerably in character, and as has been already stated, it is in places actually cut out by the encroachment of the mountain belt. On the west coast it is perhaps most typical, consisting there of the old slates and schists of the Namaqualand Series, with bosses of intrusive granite. It presents a low undulating landscape, broken by hills of granite, which in places, as at Paarl and Robertson, are conspicuous features.

Along the west and south coasts, bare sand dunes are abundant, and some of the older of these have solidified into coherent masses, which are again being cut into by the sea. On the north shore of False Bay, and near Struys Bay, Cape Colony, there are cliffs 20 to 25 feet high, formed of these old sand dunes.

Where the mountain zone has encroached on the coast, as on the shore of False Bay, and many places eastward, the Table Mountain quartzites form steep sea cliffs.

The eastern coast of Cape Colony and of a considerable portion of Natal is formed by the rocks of the Karroo, which, however, are much covered by recent coastal deposits. The lagoon landscape is particularly well developed along the Natal coast, owing to the heavy banking up of sand bars at the river mouths, while the Zululand coast is for the most part a low-lying belt.

The variation in the scenery produced by differences of climate acting on the same geological formations is again well illustrated in the coastal zone. The granitic and schistose rocks of the north-west, being exposed almost to desert conditions, show a bare and uninteresting scenery—low undulating hills with a marked absence of river valleys. From the district of George eastward, and northward into Natal, the more generous rainfall renders forest vegetation possible; the granite tors and barren schist areas of the west are unknown, and numerous rivers flow seaward in deep-cut valleys. On the Natal coast the vegeta-

Digitized by Google

tion is still more abundant, and much of that area has an almost tropical character, though the geological formations are identical with those of the barren west coast.

The Interior Plateau.—The third area—the Interior Plateau—is the most extensive, and also most varied in South Africa, showing the greatest diversity both of scenery and of geological constitution.

In the Cape Colony it consists of the Karroo, with its desert conditions, which disappear as one passes north-eastward into the Orange River Colony and the Southern Transvaal, though the same geological horizons prevail throughout these areas. Northward, the High Veld of the Transvaal consists, in addition to the Karroo Beds, of an extensive area where the older rocks, down to the oldest formation of all, have been laid bare. To discuss briefly the scenery of this vast interior plateau, it will be advantageous to deal first with the Karroo proper, and then the other areas built up of the rocks of the Karroo System.

The great Karroo is one of the most characteristic features of South Africa, and though its scenery may not be inviting, we may remember that it was the Karroo fossils sent home by Andrew Geddes Bain which first excited keen geological interest in South Africa, an interest which was stimulated on other sides by the controversy over the marvellous basal glacial conglomerate, while it was with the discovery of the Karroo diamonds that South Africa's importance to the modern world began.

The Karroo is built up of sandstones and shales which, except in the extreme south and west, where the lowest members of the series have been involved in the folding of the mountain belt, lie horizontally. Basic igneous intrusions, belonging to a late period in the geological history of the region, are everywhere abundant throughout the Karroo rocks. The Karroo scenery is a true denudation landscape. The hills which abound are remnants carved out from a surface once much higher. The flat-topped hills are in the earlier stages, the pointed ones in the later stages, of disintegration. The interbedding of harder sandstones with soft shales gives the alternate cliffs and slopes on the hillsides, while sheets of dolerite make the more marked escarpments, or krantzes.

Along the south of the Karroo, and well seen between Touws River and Matjesfontein, the slab-like weathering of the Glacial Conglomerate gives the hillsides a peculiar appearance.

The change of scenery which occurs from about the centre of the Orange River Colony northward into the central Transvaal coincides with the predominance of softer, more felspathic, sandstones, and the practically unbroken aspect of this portion of the High Veld is due to the more regular and homogeneous weathering which there occurs. There is not the same alternation of hard and soft rocks as in the Karroo proper, and the less arid climate enables the veld grass to protect the soil.

The whole of the central plateau, where the Karroo sandstones and shales form the surface, shows numerous ridges, scarcely to be called hills, which mark the site of basic igneous intrusions, which can often be traced for miles across the country. The west and south-west of the

Digitized by Google

Orange River Colony often presents what may, on a small scale, be termed quite a rugged landscape, owing to the abundant presence of dykes and small irregular bosses of dolerite and allied rocks, which, even when forming no great elevation above the general level, stand out conspicuously from the grassy veld by reason of their dark colour and their growth of sparse bush.

The central Transvaal has been largely stripped of its covering of Karroo rocks, and the old rocks appear as mountain ridges, which are in every case a re-appearance of a part of one of the older land surfaces. In this portion of the country, whether the rocks belong to the Witwatersrand System or the Potchefstroom System, the resulting scenery is practically identical—low, but abrupt, escarpments of quartzites, with dip slopes inclining north or south, and forming one side of a valley which has been carved out of the softer slates or shales. The Gatsrand, the Witwatersrand, the Witwatersberg and the Magaliesberg are all instances of this type of scenery—east and west ridges with their escarpments facing north or south according as the beds dip south or north respectively. Each intervening valley has on one side a gentle declivity and on the other a steep precipitous wall.

In contrast to the long lines of sedimentary escarpments, which make many of the hills in the southern Transvaal, are the irregular masses of Ventersdorp amygdaloid, forming the Klipriversberg and the hills south-east of Heidelberg, while north of the Witwatersrand there is the undulating landscape due to the presence at the surface of a large extent of the old granite.

Beyond the Magaliesberg, where the great Bushveld *massif* of igneous rocks appears at the surface, the landscape opens out again into the broadly undulating type. The more basic of the rocks often form hills, such as the Pyramids or Zwartkopjes north of Pretoria, but the granitic rocks give a scenery differing in no wise from that of the old granite, or, in fact, of any non-mountainous granite area. These rocks form a large part of the Bushveld proper, which in many places, with its grassy surface and irregularly dotted trees, has a close resemblance to the scenery of an English park.

Where the Waterberg formation appears resting unconformably on the Bushveld igneous rocks, or on the old granite of the north, there is a return to the escarpment and dip valley type of landscape, which is well seen in the hills north of the Premier Mine, the Waterberg itself, and the Zoutpansberg still further north. In all these hills the reddish brown colour of most of the Waterberg conglomerates and quartzites is always a conspicuous feature.

By far the larger portion of the northern Transvaal is a granite landscape, presenting over thousands of square miles a gently undulating surface, with occasional bare tors rising like inverted bowls above the surrounding country. It is, except in rare seasons, a dry country covered by straggling thorn trees, above which rise the grotesque limbs of the fantastic baóbab.

The same type of country extends northward into Rhodesia, and westward into Bechuanaland. In the former territory schist and slate

Digitized by Google

ridges often form conspicuous escarpment hills, as along the Mazoe Valley, but it is the exception to find the granite rising into elevations which might rightly be styled hills. In the Transvaal, however, east of Louis Trichardt in the Letaba Basin, there are some conspicuous granite peaks, while the Matopos and the hills of the Lomagundi district, in Rhodesia, are other instances. All these, however, differ from such mountains as the Central Alps, in being due to the denudation of the surrounding country, and they can in no sense be regarded as true mountains of elevation.

The whole of the central plateau is a poorly watered country. The Karroo, in Cape Colony, has not a single perennial stream, and the rivers of the Orange River Colony are little better. Even the Vaal and Orange Rivers are, for the greater part of each year, only a series of standing pools over a large part of their upper, and often over their lower, courses. The best watered regions are where the dolomitic limestone of the Potchefstroom System prevails, either in the southern or in the eastern Transvaal.

Few of the other rivers present much of the nature of river scenery as known in European countries. Those of the Karroo have broad shallow courses, covered with the boulders brought down in the rare times of flood. In the Orange River Colony, many of the rivers have cut deep channels through the soil and soft surface deposits, but rocky gorges are not common, though good instances may be seen on the Caledon River on the Basutoland Border.

The edge of the central plateau in eastern South Africa makes a marked physical feature, especially where it forms the great escarpment of the Drakensberg. But everywhere there is a more or less sudden drop from the High Veld down to the low country of the eastern coastal belt, whether over the basal granite, as in the Letaba Valley and at Waterval Boven, on the Delagoa Railway, or over the uppermost beds of the Karroo System, as in Natal and the Transkei.

The passage of the rivers from the central plateau to the coast zone presents considerable variation. In Cape Colony they have cut deep gorges through the Zwartebergen, Langebergen, and intervening ranges, but in Natal and the eastern Transvaal lofty waterfalls over the edge of the plateau are the common feature.

South Africa is absolutely devoid of lakes,—such bodies of water as are often designated lakes being lagoons along the coastal belt, as in the George and Knysna districts, Cape Colony, and in the case of Lake St. Lucia, Zululand; or, like Lake Chrissie, in the eastern Transvaal, they are shallow depressions filled by rain-water in the wet years—in fact, simply enlarged pans.

Many interesting observations are readily possible as to the modifications now taking place of the scenery whose geological basis I have thus briefly sketched. Over a large tract of country rock-masses break up by alternate expansion and contraction due to the wide daily variation of temperature from noon to midnight throughout a large part of the year, and whether we look at the crumbling shales of the Karroo kopjes or the massive granites of the Matopos, the same destruction is visible.

Digitized by Google

Even more obvious is the result of the torrential rains over the central plateau: we see channels cut or deepened before our eyes, and the soil of the country is carried seaward in vast quantities during every rainy season. The general surface, especially when the rain has been aided by wind, shows sometimes coverings of sand, sometimes fine gravel, decomposed from the surrounding rocks, and there are many places where this material has been accumulated to such an extent that it is often assumed to be due to an ancient river.

The intensity of these processes to-day is largely due to the scantiness of the vegetation, which is not always natural, but has been caused by the ruinous custom, almost universally observed, of burning off the grass at the end of each summer season. Instead of such senseless destruction of Nature's own protective covering, we might hope that it would now be realised that we need to add to, and not diminish, the vegetation of this part of the earth's surface. As geologists, we should willingly sacrifice our interest in observing the rapid action of denudation, when the first of each season's rains beat down on, and wash away, the soil laid bare through the destruction of grass or bush, for the knowledge that the land was not being wantonly impoverished year by year. We should even be glad to see many of these surface features, which are now so easily referable to their underlying geological features, hidden from us by a kindly growth of vegetation, and we should welcome a wise system of afforestation throughout the entire land.

In conclusion, gentlemen, I think you will agree with me that the natural and the political South Africa present some striking contrasts: geologically this part of the world has reached a maturity which no human system can hope to attain, politically the entire country is in an embryonic stage; geologically the region is the one throughout, but politically we have dismembered it. It appears almost as if Nature's plan had been too vast; her scheme too grand for poor humanity. Certainly, if the character of the people who have their home in South Africa develops in accord with the natural environment, pettiness of view or paltriness of aim will not be national traits—a country whose foundations are so wide cannot be the home of other than a broad-minded, large-hearted race, bound to play no mean part in the history of the world.

ELECTION OF COUNCIL AND OFFICE-BEARERS.

Twelve members were nominated to fill the ten vacancies on the Council, and, after ballot and scrutiny, the President declared the following to be elected: Messrs. Wm. Anderson, Geo. S. Corstorphine, J. T. Carrick, W. G. Holford, W. A. Humphrey, E. Jorissen, E. H. V. Melvill, J. H. Ronaldson, A. R. Sawyer, and F. W. Voit.

On the motion of Mr. W. G. Holford, seconded by Dr. Geo. S. Corstorphine, Mr. E. Jorissen was unanimously elected President of the Society for the ensuing year.

The retiring President then formally vacated the chair, which, in

Digitized by Google

the absence of his successor, was taken by Mr. H. Kynaston, Vice-President.

The election of three Vice-Presidents for the ensuing year was then proceeded with. Five members were nominated, and after a ballot and scrutiny, the Chairman declared the following to be elected: Messrs. Geo. S. Corstorphine, J. McClelland Henderson, and H. Kynaston.

Mr. J. H. Ronaldson was elected Honorary Secretary and Treasurer for the ensuing year.

Mr. Chas. Stuart was re-elected Honorary Auditor, and a vote of thanks was accorded to him for his services to the Society in that capacity during the past year.

The Chairman proposed a vote of thanks to Dr. Corstorphine for his past work as President of the Society. Mr. Lionel Phillips seconded, and expressed especial appreciation of the address which Dr. Corstorphine had delivered. He recalled, through the latter's references, his own knowledge of the Cape and the scenery, and described his first experiences. It was, he said, in 1875 that he made his first acquaintance with the Cape, when the railway system consisted of 45 miles to the town of Wellington. From that town their journey to the Diamond Fields was performed in ox-wagon. He described the inconveniences of the journey and the travel over the interminable Karroo. No one, however, could live for days in the Karroo without being more or less awestruck, as it were, at the immensity of this expanse of more or less desert. He would like to say one or two things, because this was a particularly harmonious gathering. One was accustomed in these days to be present at meetings that were not altogether of the same character as this one—gatherings which could be almost compared to the results which followed the effect of warlike forces in the natural world. He thought at that moment, and possibly for the next few weeks, they were to be witnesses of human convulsions of a somewhat similar nature. Of course, there was one word more that one should say. Dr. Corstorphine, in a very eloquent sentence at the end of his address, referred to the lesson that was shown by geology in South Africa, which they should take to heart, namely, that the country was meant to be one. He was sure one saw on all sides a disposition to see unity throughout South Africa again, and he believed the signs were not wanting. Efforts, he felt, would be made to bring that condition of affairs about, and they would then see a greater prosperity—a greater unity, he might say—among the people who inhabited South Africa, from which all of them wished the best of things, and with the interests of which, and the welfare of which, most of them were identified.

The vote of thanks was carried unanimously. Dr. Corstorphine expressed his pleasure at having been able to promote the interests of the Society, and remarked in concluding that he hoped that during the coming year the Society would be able to do something serious towards the establishment of a museum for Johannesburg.

A vote of thanks was passed to those gentlemen who had acted as scrutineers during the various ballots, and there being no further business, the Chairman declared the Annual General Meeting closed.

Digitized by Google

Monthly Meeting held in the Council Chamber, Chamber of Mines, Johannesburg, on Monday, 25th February, 1907, at 8.15 p.m., Mr. H. Kynaston, Vice-President, in the chair.

The Minutes of the Ordinary Monthly Meeting, held on 10th December, 1906, were read and confirmed.

The Chairman reminded members that the competition for the Draper Medal closed on the 31st March next, by which time all competing papers must be handed in. The medal presented by Mr. Draper was exhibited at the meeting.

Mr. P. A. Wagner read a paper, entitled "Petrological Notes on Rocks in the Vicinity of Craighall, near Johannesburg." This was illustrated by photographs.

Dr. J. McClelland Henderson read a paper, entitled "Petrographical Note on Kimberley Slates in the Eastern Rand."

Messrs. H. Kynaston and J. T. Carrick took part in the discussion on these papers, and a vote of thanks to the authors for their contributions concluded the meeting.

Monthly Meeting held in the Council Chamber, Chamber of Mines, Johannesburg, on Monday, 18th March, 1907, at 8.15 p.m., Mr. H. Kynaston, Vice-President, in the chair.

The Minutes of the Ordinary Monthly Meeting, held on the 25th February, 1907, were read and confirmed.

A letter was read, signed by the President on behalf of the Council and addressed to the Secretary in accordance with the provisions of Section IX., Rule 7 of the Society's Rules and Regulations, giving

Digitized by Google

notice that the Rules of the Society were to be amended, and that a Special General Meeting of Members would be convened to consider the proposed alterations as soon as they had been decided on by the Council.

The Chairman again reminded members that all papers in the Draper Medal Competition must be handed in by the 31st of the month.

Mr. J. P. Johnson exhibited specimens of diamond-bearing breccia and pebbles from Roberts Victor, Biesjesdam, and Vulcan, in the Boshof district. He presented the specimens from the two first-named localities to the Museum of the Society.

The under-mentioned gentlemen were balloted for, and elected members of the Society: Messrs. Geo. Albu, A. Trevor Roberts, and Arthur Young.

No discussions on previous papers being forthcoming, the Secretary read two papers, entitled respectively "The Cobalt Lodes of Balmoral" and "Gold-bearing Rock of the Ayrshire Mine, Lomagunda," by Professor R. Beck, Freiberg, communicated to the Society by Mr. A. von Dessauer.

Mr. E. T. Mellor spoke on the first-mentioned paper, and hoped to contribute to the discussion thereon at the next meeting of the Society.

In discussing the second paper, Mr. C. B. Kingston said:—

I had the pleasure of visiting the Ayrshire Mine and of meeting Mr. Berrington a little over a year ago.

The ore deposit impressed me as being of unusual interest, and I suggested to Mr. Berrington that a paper by him on the geology of the Ayrshire Mine would be a very acceptable contribution to the records of the Geological Society of South Africa.

The ore deposit of the Ayrshire is one of the most interesting that I have seen, if it be accepted as a fact that the gold occurs in a true diorite dyke.

I do not know of another case of gold being found in payable quantity in a diorite dyke. The uniqueness of the occurrence was commented upon in the *New York Engineering and Mining Journal* some eighteen months or two years ago in an article contributed by Mr. Spurr, late of the Geological Survey of the United States.

Three facts occur to one when considering the Ayrshire Mine, viz.:—

1. That the occurrence of gold in payable quantities in a diorite dyke is very unusual.
2. That the occurrence of payable ore bodies as contact deposits is very common.
3. That the Ayrshire dyke occurs in the contact between an immense mass of granite on the one side, and a large body of schists on the other.

These conditions suggest a case of extreme contact metamorphism. An opportunity to study the deposit from this point of view was afforded by a cross-cut that had just been driven from the heart of the ore body into the adjoining coarse-grained granite.

Digitized by Google

This cross-cut disclosed a beautifully graduated change in the texture of the rock from the fine-grained dyke rock to the coarse-grained granite.

I collected a set of samples of these rocks from which slides have been cut.

The evidence of these slides is not altogether conclusive.

The rocks are of the same general composition, the only noticeable difference being that in the dyke rock there is less mica.

The dyke rock might be described as a diorite, but it may equally well be described as an example of the extreme metamorphism of granite.

I am very pleased to find that Prof. R. Beck has determined the specimens of the dyke rock submitted to him as being samples of a metamorphic rock.

The explanation of the ore occurrence as a contact deposit appears to me to be the most satisfactory.

I regret that I have not with me to-night the samples of rock referred to, but with the hope that they may interest the members, I shall bring them to the next meeting.

Mr. R. B. Young read a paper, entitled "Notes on the Auriferous Conglomerates of the Witwatersrand," which was illustrated by several micro-photographs.

This concluded the busineses of the meeting, which terminated with a vote of thanks to the authors for their various contributions.

Monthly Meeting held in the Society's Office, National Bank Buildings, Johannesburg, on Monday, 27th May, 1907, at 8.15 p.m., Mr. H. Kynaston, Vice-President, in the chair.

The minutes of the Ordinary Monthly Meeting, held on 18th March, 1907, were read and confirmed.

The undermentioned gentleman was balloted for and elected a member of the Society: Mr. J. F. Schröder.

The Secretary then read, for the second time, a letter which the President, on behalf of the Council, had written to him, in accordance

Digitized by Google

with the provisions of Section IX., Rule 7, of the Society's Rules and Regulations, giving notice that the Rules of the Society were to be amended, and that a Special General Meeting of Members would be convened to consider the proposed alterations as soon as they had been decided on by the Council.

The following contribution to the discussion on Mr. P. A. Wagner's paper entitled "Petrological Notes on Rocks in the vicinity of Craighall, near Johannesburg," was read by the Secretary on behalf of Mr. E. H. L. Schwarz :—

With reference to Mr. Wagner's paper on the "Rocks of Craighall," I should like to ask the author whether the muscovite in the granite may not really be bleached biotite? I have been examining the Kimberley granite, and I find just such epidotised rocks as Mr. Wagner describes. In some cases the brown colour of the biotite is so faint that it may be overlooked; the epidote is derived in part from the biotite by solution, but the calcium of the epidote, I think, must, in the Kimberley granite at any rate, have been derived from outside. I should like Mr. Wagner to especially notice the partly bleached biotites, to see whether any have the extraordinary abnormal pleochroism, which I think is due to hydration to the vermiculite "vaalite." My Kimberley sections show in places little specks or flakes in the biotites, with pleochroism from riebeckite blue to yellow; only instead of having the darker colour parallel to the long axis, as in riebeckite and biotite, the absorption is reversed. This discovery of vaalite in the Kimberley granite is quite new, and has led to investigations on the micas of the pipe breccia which promise much new light on the composition of the diamond matrix. Mr. Harker has examined some of the type sections of Kimberlite which have been described by Bonney and Raisin, and finds they have in parts the abnormal pleochroism just as I found in my own specimens from the Kimberley blue and in the Kimberley granite. The importance of finding this vaalite in other granites of South Africa is therefore of very great interest. My own discovery will be shortly published in a petrographical paper on the older rocks of the Kimberley Diamond Mines, published in the Records of the Albany Museum. I wish to draw attention to this fact, because such careful investigators as Professor Bonney and Miss Raisin overlooked the vaalite in the blue ground. Tschermak saw it, but mistook its nature, and I think some of the instances of riebeckite being found in granite may in reality turn out to be vaalite. The fact of finding vaalite and diamonds in serpentine and granite contact matrices is one which must be followed up.

Rock specimens from the Ayrshire Mine were exhibited by Mr. C. B. Kingston, and the Secretary, on behalf of Mr. F. P. Mennell, read the following contribution to the discussion on Professor R. Beck's paper entitled "Gold-bearing Rock of the Ayrshire Mine, Lomagunda," which had been communicated to the Society by Mr. A. von Dessauer :—

As I gather from the last two Reports of Proceedings which have reached me that some interest seems to be taken in the auriferous rock of

Digitized by Google

the Ayrshire Mine, it may not be out of place to add the following to the list of references given in Professor Beck's paper :—

1904.—Geology of Southern Rhodesia, p. 13.
1905.—Trans. Geological Society of S.A., vol. viii., p. 87.
1906.—Proceedings of the Rhodesia Scientific Association, vol. v., part iii., p. 131.
1907.—The Mineral Wealth of Rhodesia, p. 27.

In these papers of mine the rock is described as a hornblendic gneiss or granulite. The latter term is perhaps preferable for massive contact-metamorphic rocks of this class. The evidence for a contact-metamorphic origin is complete. The rock is close (in some places within 50 feet) to a large granite mass; it is actually penetrated by small offshoots from the granite; and it contains microcline felspar, which is inconceivable as a product of crystallisation from fusion in a basic rock. It is possible, as noted in the papers quoted above, that the rock was not even igneous in its original form, as the structural evidence appears to favour the supposition of its belonging to the conglomerate series. This last, however, contains intercalated volcanic rocks, so it is perhaps unnecessary to elaborate such a point in the present state of our knowledge.

I suppose no one now doubts that the Rhodesian auriferous conglomerates really are conglomerates, in spite of the original opposition to my views on the subject. It may not be generally known, however, that the Riverlea Mine, which started crushing in March, and gave a return of over 600 ounces for that month, is treating conglomerate. This property is in the Sebakwe district, near the well-known Globe and Phoenix Mine, more than 100 miles from the Lomagunda properties of the Rhodesian Banket Company.

Mr. H. Kynaston read a paper entitled "Note on the Correlation of the Bushveld Sandstone Series and Overlying Volcanic Rocks." Specimens of rock were exhibited by the author in connection with this paper.

Mr. E. T. Mellor read two papers entitled respectively "Note on the Field Relations of the Transvaal Cobalt Lodes" and "The Geological Structure of the Middelburg District, with Special Reference to the Character, Relationships, and Thickness of the Waterberg System." These were illustrated by a map, section, and specimens.

Messrs. J. P. Johnson and H. Kynaston took part in the discussion on the last-named paper, and the meeting terminated with a vote of thanks to the various authors for their contributions.

Digitized by Google

Monthly Meeting held in the Council Chamber, Chamber of Mines, Johannesburg, on Monday, 24th June, 1907, at 8.30 p.m., Dr. Geo. S. Corstorphine, Vice-President, in the chair.

At eight o'clock, prior to the Monthly Meeting, a Special General Meeting of members was held for the purpose of amending the Rules and Regulations of the Society. At this meeting the amendments recommended by the Council, which had been previously circulated among the members, were unanimously adopted.

The minutes of the Ordinary Monthly Meeting held on 27th May, 1907, were read and confirmed.

The following gentleman was balloted for and elected a member of the Society :—Mr. W. L. Heap.

No discussions on papers read at previous meetings being forthcoming, Mr. F. A. Steart read, on behalf of Mr. H. Kynaston, a paper entitled "The Marginal Phenomena and Geological Relations of the Granite North of Johannesburg." This was illustrated by a map and specimens.

Mr. R. B. Young read a paper entitled "Note on the Alteration of the Felspars in the Felspathic Quartzite Underlying the Hospital Hill Slates," which was accompanied by microphotographs.

The Chairman stated that some time ago Mr. J. Mitford Bowker sent him some fossil bones from the farm Wiepe, on the Limpopo, Northern Transvaal, where he had been examining alluvial gravels. Mr. Bowker found in the locality a red sandstone similar to that at Buiskop, but was not certain that the fossils came out of it, as there was also a surface limestone adjoining. Dr. Corstorphine, having recognised the bones as Karroo fossil reptilia, sent them to Dr. R. Broom, of the Victoria College, Stellenbosch, for identification. Dr. Broom, in spite of the very fragmental character of the fossils, had been able to identify them as belonging to a new Dinosaur. As this was the first instance of Karroo fossil reptilia being recorded from the Transvaal, Mr. Bowker's find was of no little interest, and it was to be hoped that further examination of the district would result in other discoveries. There could be no doubt that

Digitized by Google

the fossils came from the red sandstones, which were, therefore, of Karroo, and, according to Dr. Broom, most probably of Stormberg, age. Dr. Broom had sent the following description of the fossils:—

"The collection consists of a number of bones for the most part in a very imperfect condition and considerably weathered. They appear all to belong to the same animal. Only a few are sufficiently well preserved to admit of determination, but from these few it is manifest that they are those of a large Carnivorous Dinosaur. The upper half of one tibia is in fair condition. It resembles in shape considerably that of *Massospondylus carinatus*, but is about a half larger. There are a few imperfect fragments of a femur. One claw phalanx is perfect, and there is preserved the distal end of a metatarsal bone. The only other fragment well enough preserved to be recognisable is the body of a vertebra—possibly a lower cervical. The posterior end is concave, with a further hollow in the notochordal region. The anterior end is irregularly convex, but also with a hollow in the notochordal region.

"It seems unwise to give a name to the fragmentary remains at present, as more perfect specimens will probably soon be obtained. In the meantime it is most satisfactory to know that Dinosaur remains are found in an entirely new African locality, and doubtless the same beds will yield other, and perhaps even more valuable, results.

"The beds from which the bones came must be either Upper Triassic, Jurassic, or Cretaceous. At present Carnivorous Dinosaurs are known in South Africa from the Upper Triassic beds of Aliwal North, from the Lower Jurassic beds of the Stormberg, and from the Lower Cretaceous beds of Oudtshoorn. It seems most probable that the Transvaal beds will prove to be of Stormberg Age, or Lower Jurassic. The point will be definitely settled as soon as the remains of small animals such as Crocodiles or Mammals are discovered."

Dr. Geo. S. Corstorphine contributed a paper entitled "The Occurrence in Kimberlite of Garnet-pyroxene Nodules Carrying Diamonds," and exhibited specimens in connection therewith.

Messrs. J. P. Johnson and H. Weldon took part in the discussion, and the meeting terminated with a vote of thanks to the various authors for their contributions.

Digitized by Google

Monthly Meeting, held in the Council Chamber, Chamber of Mines, Johannesburg, on Monday, 22nd July, 1907, at 8.15 p.m. Mr. E. Jorissen, President, in the chair.

The minutes of the Special General Meeting of Members and of the Ordinary Monthly Meeting, held on the 24th June, 1907, were read and confirmed.

In discussing Mr. H. Kynaston's paper, entitled "Note on the Correlation of the Bushveld Sandstone Series and Overlying Volcanic Rocks," Mr. E. Jorissen, who also referred to the remarks made by the Chairman at the last meeting of the Society, relative to a discovery of fossil bones in the Northern Transvaal by Mr. J. Mitford Bowker, said:

While on a trip to the farm Schroda (1257), Zoutpansberg District, in January last, I had occasion to study the sandstones on that and the adjoining farms, and quite agree with Mr. Bowker that these sandstones are the same series occurring at Buiskop.

Mr. Kynaston's description can be applied verbatim to the sandstones occurring on Schroda. I found there the same fine-grained uniform texture, together with the variations in colour, except that the pink and greenish tints predominate in the Schroda sandstones. Oval and spherical concretions, which greatly resemble echinoderms, abound in some of the softer beds. We find also the characteristic weathering described by Mr. Kynaston: a beautiful example of this ("fantastic monoliths") is a small hill called "Kenturk Castle."

As is the case with the cave sandstone of the Cape Colony, and with the Bushveld Series, we find that the sandstones on Schroda are overlain by a thickness of basic volcanic rock.

This rock is a beautiful porphyry with lath-shaped felspars up to two inches long. Its thickness cannot very well be determined, because, on account of weathering, there are only remnants of it on the highest points of the plateau formed by the sandstones. Even the thickness of the sandstone is difficult to gauge, because the whole area consists of it. It is, however, over 250 feet, which is the difference in level between the highest point of the plateau and the bed of the Limpopo River.

It was in the sandstone of the farm Wiepe that Mr. Bowker found the fossil bones, and, from Dr. Broom's determination of these bones, this discovery places the sandstones in the horizon of the Stormberg Series of

Digitized by Google

the Karroo System. Now in my mind there is no doubt as to the correlation of these sandstones with those of the Bushveld. Therefore I have much pleasure in supporting Mr. Kynaston's contention as to the age of the latter.

The Limpopo sandstones, as is the case with those of Komatipoort, rest on rocks of the Archæan System; they stretch right across the Limpopo into the Victoria District, Mashonaland, and it is interesting to note that coal seams are reported to occur in them in that district.

Dr. F. W. Voit read two papers, entitled respectively "Kimberlite Dykes and Pipes" and "The Origin of Diamonds."

Messrs. J. H. Ronaldson and A. Von Dessauer took part in the discussion on these papers, and a vote of thanks was passed to the author for his contributions.

The President announced that the reading of Mr. A. C. Seward's paper, on a collection of Permo-Carboniferous plants from Zululand and Natal, which was down on the agenda for that meeting, was postponed till the next meeting.

There being no further business, the proceedings terminated.

Monthly Meeting, held in the Council Chamber, Chamber of Mines, Johannesburg, on Monday, 12th August, 1907, at 8.15 p.m. Mr. R. B. Young in the chair.

The Minutes of the Ordinary Monthly Meeting, held on 22nd July, 1907, were read and confirmed.

The undermentioned gentleman was balloted for and elected a member of the Society: Mr. Thomas J. Mossop.

In discussing Dr. Geo. S. Corstorphine's paper, entitled "The Occurrence in Kimberlite of Garnet-pyroxene Nodules carrying Diamonds," Mr. H. S. Harger, who exhibited numerous specimens in support of his remarks, said:—

In this paper Dr. Corstorphine refers to a garnet-pyroxene rock carrying diamonds, which was found in the Roberts Victor Mine in the Orange River Colony, and which rock, in his opinion, closely agrees with an eclogite boulder from Newlands Mine, which Professor Bonney also found to contain diamonds.

Digitized by Google

The latter, however, was apparently so much rounded that Professor Bonney expressed the belief that it was water-worn, an opinion which appears to have been formed mainly on its external appearance. The smooth and worn condition of a boulder which could lead a careful observer like Professor Bonney to suggest that it was *water*-worn, must be kept in view when theorising on the origin of pyroxene or eclogite boulders in kimberlite.

With this and similar evidence before him, however, Dr. Corstorphine attempts to show in his paper that the pyroxene-garnet boulders in the Roberts Victor and other mines are not boulders, but nodules or concretions, due to magmatic segregation. That theory is of very great importance, and this is my excuse for entering somewhat lengthily into the discussion arising out of Dr. Corstorphine's paper. The settlement of this question will go a long way towards settling a still more important one, namely, the genesis of the diamonds found in the kimberlite.

Taking some of Dr. Corstorphine's statements in their order, the first on which I wish to comment is his "negative arguments" against Professor Bonney's opinion that the diopside and garnets of the pipe breccias originated from an eclogite. In connection with this, Dr. Corstorphine relies largely on the fact that "in no part of South Africa has an eclogite mass been observed." This latter statement I believe to be wrong, as Mr. M. E. Frames informed me some years ago that he found a beautiful eclogite outcropping somewhere near the Orange River in Griqualand West. Mr. Frames will doubtless confirm this. In the next paragraph Dr. Corstorphine says "the foreign rocks which are found in blue ground are conspicuously normal, in fact I have never seen any fragments showing a trace of igneous alteration." If the author refers to diamond pipes containing *blue* ground I quite agree with him; but if he includes the fissures or dykes I cannot, as I have good evidence of metamorphism, due to the heat of fissure kimberlite, in the form of sandstone altered to quartzite. The fragments are round, and show concentric zoning or banding, due apparently to external heating, the outerlayers splitting off concentrically, like the weathering of a dolerite boulder. The surface is also very rough and corroded, as one would expect if the rock had been caught up and entombed in a molten magma. I place some of these fragments on the table, all from fissures on Voorspoed, Normandien, and Baltimore, Orange River Colony.

Now in connection with Dr. Corstorphine's statement that no signs of heat can be found in the blue ground, I would ask what sort of a magma the kimberlite was, if it had not sufficient heat to cause any metamorphism of included fragments and minerals, and yet could lend itself to magmatic segregation? I should have thought an igneous magma in which such marked differentiation as Dr. Corstorphine suggests took place, would have been in a molten condition; indeed, I think the hard forms of kimberlite (termed "hardibank") were undoubtedly in a molten condition, containing less steam and water than the blue ground; and that alone seems to me an explanation of the reason why blue ground is soft and earthy, and disintegrates on exposure, whereas the "hardibank" will

Digitized by Google

not disintegrate at all. Moreover, the chemical composition of the different kinds fails to account for the difference in the hardness, as I have previously shown before this Society. Again, as the dyke kimberlite is usually of the hard description, it seems to me that heat, not chemical composition, will best account for hardness. I have placed a specimen on the table which was taken from the Vogelfontein Mine, near Jagersfontein. It is a dark, very hard form of kimberlite. One-half consists of a coarsely porphyritic magmatic rock, whilst the other portion is very fine grained, appears to have cooled off quicker, and contains a band-like aggregation of serpentinised minerals strongly suggestive of segregation. I would certainly say this form of kimberlite had been subjected to great heat, as I find, in addition to the foregoing, a peculiar zoning around the edges of included fragments. Sometimes as many as six distinct alteration zones can be observed, as in another specimen from Vogelfontein which I place before you. In this piece heat is not only suggested by the alteration zones of included fragments, but the rock, being of the kind which appears to have been highly heated, lends itself to the magmatic segregation suggested by Dr. Corstorphine. An examination of this rock shows numerous roundish concretions of a yellowish mineral, which might be olivine or a pyroxene, and this mineral seems to pass by degrees into the surrounding darker matrix. There is also usually a distinct zone of a darker mineral (which is also plentiful in the matrix) around the concretion. In addition to the latter will be seen a roundish concretion about an inch across, of the same yellowish green mineral referred to above, but containing also a number of blood red pyropes and some emerald green pyroxene resembling smaragdite. This is one of the garnet-pyroxene rocks so often found in diamond mines, and as it ocurs in the hardest form of kimberlite and is associated with little nodules, which might well be magmatic concretions, I think Dr. Corstorphine will look upon it as evidence in support of his theory. I also place on the table a hard blackish specimen of kimberlite from Zonderwater Mine, near Pretoria. This also contains an aggregation of green minerals which might be due to magmatic segregation. I have placed these specimens before you because they happened to be in my collection of diamondiferous rocks, and might assist Dr. Corstorphine and other members to form conclusions. On the other hand I have brought some specimens which in my eyes are evidence quite in opposition to the theory that all the pyroxenes, mica, garnets, etc., were formed *in situ* in the blue ground. Some of these minerals doubtless were formed in the magma, but others are foreign inclusions, as I hope to prove.

Referring to the rounded character of the garnet-pyroxene nodules or segregations, Dr. Corstorphine says: "The generally rounded character of the nodules and the peculiar appearance of the outside of the garnets is typical of such segregations, and is not due to water action." He adds that they appear rather to have been corroded, and continues that in some cases the garnets, and in others the pyroxenes, have been the more attacked, the one mineral standing out at times more prominently on the surface than the other, etc. He attributes this to percolating water.

Now I have before me here one of the nodules to which Dr. Corstor-

Digitized by Google

phine refers—it is from the Roberts Victor Mine. The garnets with which it is so closely studded projected more than the other minerals. I have not had a thin section made, but macroscopically the rock contains a brownish red and orange red garnet, a transparent to translucent green mineral (probably chrome diopside), and at one end a large proportion of light grey mineral (probably the felspar of Dr. Beck). There is also cyanite. This rock closely resembles Dr. Corstorphine's diamondiferous garnet-pyroxene nodule, only there is more grey and less green mineral. I have not the slightest doubt that the diamondiferous rock referred to by Dr. Corstorphine is very closely allied to the cyanite-bearing rock examined by Dr. Beck. I have got all of them in my collection, and find there is no sharp line of demarcation between them. The garnet-pyroxene rock passes gradually into the beautiful cyanite-bearing felspar rock of Dr. Beck, and one hand specimen in my collection contains both. Dr. Corstorphine says nothing about the latter nodules, and I would like to know if he includes it with the pyroxene-garnet rock as a segregated nodule? Now the specimen to which I am referring is a piece broken off by myself from a large oval-shaped boulder about twelve inches long, nine inches broad, and about 4½ inches thick. On one of the flat sides, almost in the middle, and following the longest axis of the boulder, was a deep groove about 1¼ to 1½ inches wide and ⅜ inch deep. This groove follows the whole length of the rock, and presented the appearance of having been scored whilst being forced between two rocks or past some projecting hard rock in its passage to the surface.

On the opposite side of the boulder is a similar but smaller groove. Another boulder of the same kind shows four parallel grooves, each a little smaller than the last. If these are magmatic segregations I would like Dr. Corstorphine to explain the deep scoring seen in the first-named specimen.

I have also placed on the table two pieces of garnet-diopside rock from Jagersfontein, one of which contains graphite. They are of the same description as those found in the Roberts Victor Mine, but minus cyanite or felspar. These boulders remind one of Professor Bonney's eclogite, being so smooth that they might have been water-worn. The outside garnets do not contain kelyphite rims, and the surface of both garnets and diopside are quite polished. If these are magmatic segregations it is surprising that the faces of the specimens are so very smooth, showing no influence whatever due to allotriomorphic structure of the minerals surrounding it and from which they had separated. Dr. Beck's conclusion as to the origin of the cyanite-bearing rock (which I believe has exactly the same origin as Dr. Corstorphine's garnet-pyroxene rock), was as follows: "The structure of the rock gives one the impression that an old cyanite-garnet rock had been included in a diabase eruptive magma, and thus undergone contact metamorphism."

I will say nothing about possible metamorphism, but suggest that if an ultra basic magma in which felspar and cyanite are a quite *negligeable* quantity, can segregate felspar-cyanite-garnet nodules, so is there a chance of grooved pyroxene-garnet rocks having been brought up in the magma, as pointed out by Dr. Beck. Now in support of the latter theory, and in

Digitized by Google

opposition to the idea that all the minerals of the blue ground crystallised *in situ*, I wish to draw attention to a most interesting occurrence in the Zwartrandsdam Mine. On the table is an oval-shaped flat block of light brown mica, of the vaalite description so common in our kimberlite. It measures 7 inches by 4 inches by 2½ inches, is oval in shape, and is a portion of a once larger piece, having been broken by myself. The leaves of the mica appear to have been the full size of the entire block, and have been broken off abruptly at the extreme ends. The fragment shows numerous cracks, filled in with calcite, in addition to the numerous parallel lines due to the lamellæ. It has a somewhat fibrous structure in parts, and the leaves and fibres are, in places, bent and broken. If this block had consisted of numerous small flakes and crystals of mica, it might have been said that this boulder had crystallised in the blue ground, but the large size of the leaves and their twisted and broken condition is opposed to such a theory. The next piece is a weathered block of the same mica, showing more distinctly its crystal form. It is not oval and rounded like the last, but rough and jagged and more fibrous, the latter appearance being apparently due to a cross cleavage like the characteristic cleavage cracks in a perpendicular section of hornblende. The leaves and fibres have been abruptly broken off on all sides, and portions of the block show the leaves to be broken, bent, and twisted. It closely resembles a fragment from one of the old crystalline schists, which we know underlie the younger formations of the O.R.C., as I will presently prove by some hand specimens. Now this fragment of mica schist, contains a few isolated pieces of emerald green pyroxene (diopside) of precisely the same description as found in nearly all the big mines. The next few pieces of this mica schist contain about fifty per cent. of the bright green pyroxene, and the mica is seen in smaller crystals. There is also a yellow decomposed mineral, which is too much oxidised for identification. The next piece belongs to the same series, but contains more of the yellow oxidised mineral and less pyroxene. This fragment also contains graphite in two places, and this graphite is in precisely the same foliated form as that in some Jagersfontein garnet-pyroxene rock which I also place before you. The next piece is still of the same series, but contains many brownish red garnets, in addition to plenty of green pyroxene, and more closely approaches Dr. Corstorphine's garnet-pyroxene rock. Next comes a fragment consisting almost entirely of emerald green pyroxene. Now specimens like the latter occur plentifully in Jagersfontein, the Roberts Victor, and other mines, and in the latter mine I saw a rounded boulder of this description fully eight inches in diameter. This I presume would have to come in with the other nodules referred to by Dr. Corstorphine as segregations. But I am not prepared to accept such a source for my samples from Zwartrandsdam Mine. I consider they much more resemble fragments torn from a crystalline schist formation below, and moreover both the mica and the pyroxene have a tendency to show crystalline form and crystal faces. In addition to that numerous fragments of gneiss and other crystalline schists are found in Zwartrandsdam and some other small mines close to it, indicating that crystalline schists exist below.

Digitized by Google

Now although I am not opposed to the theory of magmatic differentiation in some of our mines, more especially those in which there is evidence of great heat, and also evidence of magmatic segregation, I do object to any theory which attributes one origin only for the minerals found in our pipes. The pipes have burst through the earth's crust, breaking up many different kinds of rocks, some of which are composed largely of such minerals as pyroxene, garnet, and mica, which is freely distributed throughout the blue ground. In proof of this I place on the table the following hand specimens: White, coarsely crystalline granite, large block of biotite mica, mica schist, amphibolite schist, banded gneiss, from Koffyfontein and Ebenhaezer group; garnetiferous mica schist (in which the garnets are very numerous) from Jagersfontein; granites (grey and pink), graphic granite, hornblende syenite, granulite (apparently full of garnets, but this remains undetermined), massive hornblende, hypersthenite(?), igneous breccia, dolomite, diabase, quartzite, and boulders of fissure kimberlite, all from Voorspoed Mine. Now all the foregoing are foreign rocks—that is, inclusions of rock fragments in the blue ground—and no one would suggest that they are segregations. If carefully examined it will be found that they have all been rounded by attrition—some, indeed, are as smooth and round as if water-worn—for instance, the hypersthenite, dolomite, diabase, and quartzite boulders. All the foregoing rocks, on being fractured, would yield rough angular fragments, yet when found in the blue ground they are rounded. The quartzite and dolomite would give distinctly sharp, angular fragments on being broken, yet we find them as rounded and almost as smooth as river pebbles. It must be admitted that these rocks have been rounded by attrition in the pipes; are we then to suddenly draw a sharp line and say "although the foregoing basic and acid rocks have undoubtedly been rounded, and have come from below, the eclogites, pyroxenites, and lherzolites have *not*, but have crystallised in the blue ground"? If such is to be the case, and we declare that all the millions of garnets, pyroxenes, etc., have crystallised in the kimberlite magma, I would ask, is it not remarkable that barely *one* of those garnets or pyroxenes out of millions had succeeded in showing their crystal faces, where the diamonds *have* succeeded in doing so? Now, as Dr. Corstorphine says, on the view that the garnet-pyroxene boulders containing diamonds are concretions in the kimberlite magma, the presence of diamonds in them supports the theory that the diamond originated in the blue ground. This theory is supported by Dr. Voit, in his recent paper on "The Origin of Diamonds," who, having decided that the diamonds did crystallise in the blue, says: "The first minerals crystallising out were, *of course*, diamonds, as these can stand the greatest heat, after which garnets, pyroxenes, micas, etc., were formed as minerals, whose stability towards heat is not so great." This statement is intended to bear out Dr. Corstorphine's theory, but no evidence is given in support of it. Against that statement of Dr. Voit's I wish to refer you to Mr. Gardner F. Williams, in "The Diamond Mines of Kimberley" (*Science in South Africa*, page 329). He there gives evidence of a diamond weighing 114 carats, in which was embedded a garnet weighing about half a carat. The garnet appeared to fill the hole in which it was embedded.

Digitized by Google

The diamond contained other similar holes or depressions, and Mr. Williams thought those holes also contained garnets. He concluded that the diamond crystallised on a nest of garnets. In any case here is evidence which certainly points to the garnet having existed and crystallised *before* the diamond. Mr. Williams further says: "There is conclusive proof that the diamonds in the South African Mines are not found in their original place of crystallisation, as, for example, the frequent occurrence of *broken crystals embedded in hard kimberlite.*"[1] This statement is very weighty, coming as it does from Mr. Gardner Williams. It is also supported by Mr. C. Wilson Moore,[2] and I have personally seen a broken diamond picked out of soft yellow ground (oxidised kimberlite) in the Voorspoed Mine, before any explosive or machinery had ever been used on the mine. The Cullinan diamond, which was only a portion of a larger stone, was picked out of the mine face with a penknife, and I am informed by one of the Directors that the ground had not been blasted just there. I recently examined 372 diamonds taken from a large parcel; one hundred and nineteen were broken. Many broken diamonds have been found in the mines, and that was one of the principal reasons why geologists discarded the theory years ago of crystallisation *in situ*, and looked for some other solution of the problem. Sir William Crookes says: "It has been *conclusively proved* that the diamond's genesis must have taken place at great depths, under enormous pressure. The explosion of large diamonds, on coming to the surface, shows extreme tension."[3] Mr. Waldemar Lindgren, after studying forty-five slides sent by Mr. Gardner Williams, said: "It is not possible to regard it (the diamond) as formed in the blue ground."[4]

Although I do not agree that all the pyroxenites and similar rocks are concretions, I admit that some of them might be, and think no hard and fast line should be drawn regarding the many different kinds of ultrabasic boulders, concretions, etc., which the ground contains. The mines vary greatly in their characteristics; some contain highly brecciated, impure kimberlite of volcanic origin, which would not readily lend itself to magmatic segregation; and others contain a clean, hard porphyritic kimberlite, which I certainly believe did lend itself to magmatic segregation. Whether or not the diamond crystallised in the magma after it reached the earth's surface, still remains to be proved. Although I at one time, like other geologists, sought a different solution, owing to the alleged presence of broken diamonds in the blue, the study of kimberlite fissures in the last few years has inclined me towards Dr. Corstorphine's way of thinking, though the actual evidence he gives in support of his theory seems weak. When Dr. Corstorphine can examine his diamond-bearing pyroxenite in a hard blue ground or "hardibank," and show marginal phenomena or uniform orientation of minerals around a nucleus or some other unmistakable evidence of magmatic segregation, he will

[1] "The Diamond Mines of Kimberley," by G. F. Williams, in *Science in South Africa* (1905), p. 324.

[2] "Minerals of Southern Africa," by C. Wilson Moore and Wilmer (1893), p. 22.

[3] "The Diamond Mines of Kimberley," by G. F. Williams, in *Science in South Africa*, p. 329.

[4] *Ibid.* p. 329.

Digitized by Google

have gone a long way to settle the problem of the origin of diamonds; but it seems to me that opinions formed on boulders or nodules of pyroxenites and eclogites, which have weathered in the very soft yellow ground of the Roberts Victor Mine, can hardly be accepted as conclusive, although very interesting, and of great importance. In conclusion, I wish to thank Dr. Corstorphine for opening up a new and valuable field for geological thought and study in connection with the diamond formations of South Africa.

Dr. F. W. Voit also took part in the discussion.

In connection with this paper, the Chairman announced that it would be open for discussion at the next meeting, in consideration of the fact that advance proofs had only reached the hands of members a few days ago.

Dr. C. Sandberg submitted a discussion on Dr. F. W. Voit's paper, entitled "Kimberlite Dykes and Pipes." He said:—

Dr. Voit's very able paper on the above subject has brought us a long step further towards the solution of the geological questions connected with the interesting occurrence of the diamond-bearing rock. His patient and laborious accumulation of data and his clear exposition deserve all credit and appreciation.

I only wish to touch upon a few points in his paper which still seem open to controversy, leaving the full treatment of the questions involved to some later date.

According to Dr. Voit the occurrences of kimberlite in pipes and in dykes (or fissures) are not contemporaneous, the pipes being younger than the dykes. This view is shared, I believe, by a number of our local colleagues, and was originally based upon the fact that fissure-rock has occasionally been found in pipes, whilst pipe-rock is supposed to be totally absent from the fissures. The fact mentioned by Dr. Voit, of the abrupt ending of fissures when coming into a pipe, is brought forward by him as additional proof in support of this contention.

When basing our ideas on Daubrée's generally accepted theory, according to which diamond pipes originated by the violent explosion of gases, accumulated under high pressure, bursting through the overlying strata, we must bear in mind that our French master founded his theory on the assumption that these strata were still unbroken. His now classical experiments clearly showed this, because, in demonstrating the probable correctness of his theory, he took a plate of glass, which was sound and showed no cracks or fissures.

A violent explosion on such a piece of glass produced a round hole, "diatrème," the rim of which was not bent or contorted, any more than are the sedimentary strata round those curious volcanic necks in Fifeshire and Mid and East Lothian, the maaren in the Eifel, and the kimberlite pipes here.

Daubrée's theory was the more readily accepted as it soon became evident that these necks and maaren were *not* situated on the lines of pre-existing fissures or faults, so that his experiment could justly claim to have been executed under conditions similar to those existing in nature prior to the formation of those necks and maaren.

Digitized by Google

On the other hand it is daily proved in mining that a violent explosion in fissured rock never produces a round hole. The gas pressure, not being able to concentrate on one spot, is rapidly diffused along these pre-existing fissures, *i.e.*, along the planes of least resistance. If thus we were to admit the existence of the kimberlite dykes prior to the formation of the pipe, we could never explain the generally rounded and always sharply defined shape of the latter to have been the result of a violent explosion. Neither could the fissures end so abruptly in the pipes as they generally do, and the pipes would almost invariably be found to overlap and intrude upon the fissures.

Basing, therefore, our idea on Daubrée's theory (and we have no better to substitute for it at present), the fissure could not have been pre-existent to the pipe.

Let us now investigate the contention which first originated this theory—non-contemporaneity.

That pipe matter is non-existent in fissure magma is a statement I must reject as not being founded on sufficient evidence. For, apart from the fact that pipes have been more thoroughly explored than fissures, and that, consequently, we have had more chance of finding fissure-matter in a pipe than *vice versa*, we must admit that the above contention is not borne out by facts.

Dr. Voit seems to acknowledge this himself, for he says: "There is no doubt that in some cases pipe-rock and fissure-rock resemble each other . . . . . and it would be very difficult sometimes to say from a hand specimen whether it belongs to a pipe or a fissure."

I think that we can henceforth safely eliminate the supposed non-existence of pipe-rock in kimberlite dykes as an argument tending to prove the existence of the fissure prior to the formation of the pipe.

It must be acknowledged, however, that in general pipe-rock and dyke-rock differ considerably mineralogically. Still there is no room for doubt that they belong to the very same magma.

The magma came up, cooled, and crystallised in a very narrow mould in the case of the fissure, whilst it did so in a very much larger mould in the case of the pipe. The injected kimberlite magma would cool down far more rapidly in a fissure than in a pipe, and a difference between the texture and the structure of the solidified magma of the pipe and that of the fissure would be the result; a difference similar to, although not so pronounced as, that which exists between an effusive and a batholitic rock.

The combinations of the constituting elements of a homogeneous magma in the way of crystallisation, are different in those parts of that magma which are subjected to different conditions, and the minerals engendered in the one part may thus be totally or nearly entirely absent in the other.

Lastly the experiments of Frémy and Morozowicz have clearly proved that minerals develop better and larger forms when allowed to crystallise in a large mould than in a narrow one. This would explain the marked difference in the mineralogical constitution and in the size of the same constituent minerals of pipe-kimberlite and dyke-kimberlite.

Digitized by Google

The presence of dyke-kimberlite in pipes can be easily and naturally accounted for, as the product of patches of kimberlite magma which were retarded in their crystallisation, and which only crystallised after the surrounding magma had already been solidified.

Dykes must either have been contemporaneous or perhaps possibly older than the pipes, certainly never younger. Personally I am satisfied that they are contemporaneous.

The main strike of the dykes is parallel with the direction of the axes of the folds of the region.

The eclogites, I feel convinced, must be looked upon as segregations of the original kimberlite magma.

With reference to the origin of diamonds, I think it very gratifying to note that the idea expressed by Prof. A. Lacroix some four years ago is gradually gaining ground, and that before long we may definitely look upon this precious mineral as an original constituent of the kimberlite magma just the same as the garnets, pyroxenes, etc.

The chips and fragments will then no longer be looked upon as so many pieces broken from originally well-shaped crystals, the missing parts of which were conjured away, but simply as imperfectly crystallised diamonds.

Mr. J. P. Johnson also took part in the discussion.

A paper entitled "On a Collection of Permo-Carboniferous Plants from the St. Lucia (Somkele) Coal Field, Zululand, and from Newcastle District, Natal," by Mr. A. C. Seward, F.R.S., Professor of Botany, Cambridge (hon. member), was read on behalf of the author by Mr. William Anderson. This paper was illustrated by plates.

Mr. T. N. Leslie briefly discussed this paper.

A paper entitled "Note on the Lherzolite and Eclogite Boulders of the Roberts Victor Mine," was read by Mr. J. P. Johnson.

Dr. F. W. Voit read a paper entitled "Gneiss Formation in Africa," which was accompanied by a section.

The meeting terminated with a vote of thanks to the various authors for their contributions.

Digitized by Google

Monthly Meeting held in the Council Chamber, Chamber of Mines, Johannesburg, on Monday, 9th September, 1907, at 8.15 p.m., Mr. E. Jorissen, President, in the chair.

The Minutes of the Ordinary Monthly Meeting held on 12th August, 1907, were read and confirmed.

The following gentleman was balloted for and elected a member of the Society:—Mr. J. S. Celliers.

The Chairman announced that the two papers down on the Agenda in Mr. Mellor's name, viz., "The Older River Gravels of the Limpopo Valley," and "Note on the Karroo System in the Northern Transvaal," would not be read at that meeting.

The following contribution to the discussion on Dr. Geo. S. Corstorphine's paper entitled "The Occurrence in Kimberlite of Garnet-Pyroxene Nodules carrying Diamonds" was read by the Secretary in the absence of the writer, Mr. E. H. L. Schwarz:—

With reference to Dr. Corstorphine's paper on the Garnet-Pyroxene Nodules carrying Diamonds, and the occurrence in them of Cyanite, I should like to place on record that there are similar nodules from Jagersfontein in the Albany Museum. I have not yet detected diamonds in these latter. They were given some years back by Mr. Wagner, and were identified as nodules containing sapphires. I suspect that it was these that gave rise to the report that sapphires were found in the Jagersfontein Mine, as stated in Mr. Gardner Williams' book on the Diamond Fields. I call the Jagersfontein stones cyanites, because they are the same as the Roberts Victor blue stones, but they differ materially from normal cyanite. For instance, the specific gravity of the isolated grains is 3·8, and the hardness goes as high as 8 on the macropinacoid, that is, the face giving the axial figure in convergent light. Personally I believe we are dealing with a new mineral, one which, perhaps, is a mixture of sapphire and cyanite. Many true sapphires are biaxial, the anomaly being usually explained by the interposition of twin lamellae, but it is quite possible that in some cases it may be due to the presence of a certain amount of silicate. When strongly heated the stones turn colourless, but regain their colour when cool.

Digitized by Google

In connection with the same paper Mr. R. B. Young called the attention of members to a note "On the Geology of the Eastern Portion of Griqualand West," by Mr. A. L. du Toit, which was included in the Eleventh Annual Report of the Geological Commission of the Cape of Good Hope.

In discussing Dr. F. W. Voit's paper on "Kimberlite Dykes and Pipes," Mr. A. von Dessauer said:—

It is to two points in Dr. Voit's paper on "Kimberlite Dykes and Pipes" that I wish to confine the following remarks. These are the same two points which already struck me as rather irreconcilable when listening to Dr. Voit, but now, when I have his paper in print before me, they appear to me still more so. In fact, I fail to understand how they can possibly be maintained at the same time. These two points are:

The pipes, according to Dr. Voit, are conical batholites; they are intratelluric, volcanic embryoes. The roof which existed therefore over every one was destroyed by denudation of the original summits in almost every case, except at some mines where still portions of it are preserved, such as the Voorspoed, the Jagersfontein, the Lace, and Lion Hill, and the Theron pipe, where practically the whole roof is still intact. The rocks of the roof were only rent by cracks and faults, in some cases few in number and small and narrow in size; in others by innumerable ascending fissures pinching out towards the surface.

The other point is his explanation of the formation of the pipes, which he attributes to the magma having been blown through the formation with great force, as in this way only could these clean, circular holes have been drilled. He describes, at other places in his paper, that this occurrence was an extrusion of a somewhat violent character, or took place in a more cataclysmic way.

I have pointed out before that these two statements cannot be reconciled in any way. The cavities of the various pipes represent in each instance an enormous volume.

It is instructive to calculate this volume of the various conical cavities and of the corresponding masses of rock which must of necessity have been removed if an explanation of the origin of these cavities through widening of a fissure is disallowed. I shall assume a depth of only 5,000 feet, and allow for a retention as exotic enclosures in the present kimberlite of 10 per cent.; the latter figure, you will agree with me, is exceeding the actual conditions. The rocks removed are:—

For the Lace Mine	800,000,000	cu. ft.
For the Jagersfontein Mine	2,300,000,000	„
For the Voorspoed Mine	2,600,000,000	„
For the Premier Mine, Transvaal ...	7,000,000,000	„

I have not been able to obtain any authentic data of the size of the other pipes which Dr. Voit mentions as living examples of roofed pipes, namely, the Theron, Lion Hill, and Loxtondale, although such a calculation in the instance of the Theron (Kimberley West) would have been most convincing, because Dr. Voit states that the only channels through which these masses of rock could have been removed "are pinching out towards the surface."

Digitized by Google

Dr. Voit states that he cannot understand how the idea prevailed for so long that pipes and dykes were contemporaneous, and that the pipes were nothing but widenings of the fissures. These cavities have, in his opinion, not been formed by a gradual receding of wall from wall, by an opening out of a crack or rent, or a cross of such two, but he states repeatedly that they are the result of an explosion of terrific force. The only possible explanation, in the light of this statement, is that the material which once occupied the place of these cavities must have been removed forcibly.

But Dr. Voit does not venture any explanation of what became of this material; it simply disappeared or vanished.

If we accept his explanation of the formation of the pipes "through a violent explosion on a point of special weakness, as represented usually on a pre-existing fissure," the only possibility of explaining the disappearance of these many hundreds and thousands of millions of cubic feet of rock is that they were ejected forcibly in advance of the ascending magma. Under these circumstances the theory of roofed pipes or batholites is untenable. An open crater must have been the result. No roof could have withstood the force and impetus of such moving masses. It is hardly necessary to prove this by showing the actual figures of the power that was required to break out of its natural connection and cohesion, to lift several thousand feet, and to remove the 2,300,000,000 cubic feet of rock in the Jagersfontein Mine, which Dr. Voit gives as an illustration of a still partly roofed pipe. Such figures would prove conclusively that it was impossible for a few feet of basalt or shales to remain intact in their original position over a crater emitting such enormous masses with such force. One could just as well look for a spider web across the muzzle of a 12-inch gun after firing the shot.

There is, therefore, in my opinion, only one alternative for Dr. Voit: to abandon either the theory of the formation of the pipes by violent explosions, or his theory of the embryonic volcanoes or batholites.

There are very few to my knowledge who will agree with Dr. Voit in seeing in the Voorspoed and Jagersfontein Mines roofed pipes. The presence of the floating diabase and basalt, of the island in the De Beers Mine and other large masses of floating reef, is usually explained in a different and less strained way. The other three mines mentioned by Dr. Voit, the Lion Hill, the Loxtondale, and perhaps also the Kimberley West, are, so to say, still *sub judice*.

It is with great interest that I look forward to Dr. Voit's attempt to reconcile these points.

Messrs. H. L. Krause and H. S. Harger also took part in the discussion on this paper.

Mr. H. L. Krause said:—

I congratulate the author on having succeeded so well in reviving our interest in a subject of great scientific and economic importance, and on his able efforts to bring us somewhat nearer a solution of a complicated problem. If I am unable to follow the author in every turn,

Digitized by Google

especially where the strength or weakness of a statement depends on the degree of precision with which it is put, it is partly because I, probably with others here, have not had the advantage of studying the geological conditions dealt with in the paper, on the spot.

I would draw attention to one or two points on which further explanation seems to me desirable.

(1) Dr. Voit's definition of the pipe rock as a "peridotite breccia," after it was referred to by him and others as a "brecciated peridotite," is confusing. Is it a breccia by reason of the enclosure of blocks of granite, gneiss, floating reef, and other wall rock, in a base of intrusive matter (peridotite), or is it that the peridotite mass itself, after being fractured and fissured, contains interstitial matter of foreign origin? In either case, whether the eruptive rock constitutes the elastic portion or the cementing portion of the breccia, the term "brecciated peridotite" is clearly inappropriate.

To take an illustration from another part of our neighbourhood: The layers of breccia commonly met with at the base of the Pretoria Series are made up of angular pieces of quartz, hornstone, and chert, set in a cement of essentially lime-magnesia carbonate. It is, tersely put, a dolomitic quartz breccia. The elastic part of the rock is easily distinguished; the quartz is fragmentary, angular, elastic, what you will, but it is certainly not brecciated. The cement, on the other hand, proves, on microscopic and chemical examination, to be an aggregate of dolomite grains and interstitial matter, the latter composed of opaline silica with silicate and carbonate of lime and magnesia. It is a genuine brecciated cement, but to call it a brecciated dolomite would be both inaccurate and misleading. To trace the genealogy of this rock is a question that needs not only attentive observation in the field and laboratory, but involves critical consideration of its geo-chemical and dynamical bearing; and surely nobody expects to have a synopsis of all this laborious research crowded into two or three words. The term "dolomitic quartz breccia" may be sufficiently explanatory from a geo-tectonic aspect, but it conveys no meaning as far as the derivation and history of the rock are concerned.

I apologise for an apparent digression, whilst disagreeing with the terms in which Dr. Voit has chosen to put his definition of the pipe kimberlite, in the concluding paragraph of his paper on "Kimberlite Dykes and Pipes."

(2) While most of us seem agreed in considering the contents of the diamond pipe to be a brecciated mass of material, partly elastic and partly eruptive, opinions are divided on the question: how much of that material—or, specifically, which of its constituents—owes its presence to magmatic differentiation, which to segregation, and which to mechanical transportation? In the view of the author and that of Dr. Corstorphine, the pyroxene-garnet aggregate, found in detached spherical lumps in the gossan of the pipe deposit, is the outcome of segregation, and it seems to me the available evidence is for the most part on their side.

An objection might reasonably be urged against the use of the name "eclogite" for that rock, on the ground that it applies to a species

Digitized by Google

hitherto only met with in crystalline-metamorphic country—granulites, gneiss, mica schist. (Possibly it was the association of ideas which suggested the abyssal origin and "boulder" theory to Mr. Harger). In the typical eclogite the essential constituents, omphacite (a monoclinic, but otherwise nondescript pyroxene) and magnesia garnet, are always devoid of outward crystal form, a feature repeated in our Kimberley rock, as is also the occurrence of kyanite, mentioned by Dr. Corstorphine. On the other hand, hornblende, rutile, muscovite, and magnetite, which are all but constant accessories in the typical eclogite, are apparently absent from our rock. Granted that both rocks were produced under similar chemical conditions, the respective geological conditions present such fundamental differences, that it is hard to see under what system the two types can be ranged together. Dr. Corstorphine attaches, perhaps, an undue importance to the occurrence of "kelyphite" crusts on the garnet blebs when he declares it to be "typical of concretionary structure." The phenomenon appears to be peculiar to all pyrope, wherever it exists, either in serpentine or eclogite, and is generally attributed to incipient transmutation, the ultimate products being amphibole and spinel—in our own case, perhaps, biotite and diopside. Regarding the question whether these spherical masses are concretions or boulders, I would like to ask Dr. Corstoprhine whether he has observed any radial arrangement in the mineral grains of these balls, so characteristic of concretions? Our difficulty will certainly be lessened after we have come across a specimen *in situ*, with its host in an unweathered condition. If the contention be correct that biotite + olivine = omphacite + pyrope, *i.e.*:—

$$K_2\,Al_6\,(Fe\,Mg)_{12}\,Si_6\,O_{34} + (Mg\,Fe)_2\,Si\,O_4 =$$
$$(Ca,\,Mg,\,Fe)_3\,O_9\,(Si_3\,O_6,\,Al_4\,O_6) + Mg_3\,(Al_2)\,Si_3\,O_{12}$$

then we should expect to find around the concretion a zone richer in Fe and Mg, but poorer in $Al_2\,O_3$ than the normal kimberlite into which it passes beyond. If these diamond-bearing rounded pieces should, contrary to present evidence and belief, turn out to be blocks travelled from below the region of crystalline schists, then the views which many of us entertain now regarding the origin of the diamond in the kimberlite pipes would have to be greatly modified.

(3) Dr. Voit's account of the juxtaposition in space of the kimberlite dykes and pipes may be taken as conclusive, but he draws from it certain propositions which are not entirely convincing. He assumes that the dyke rock and pipe rock have sprung from the same ferromagnesian magma, but that they are not coeval; that the former is an effusive (volcanic) product; and that the latter is an intrusive (plutonic) product, presenting, however, a distinct volcanic aspect.

Regarding these and some other points brought out by Dr. Voit's paper, I fear it is impossible at present to raise them from the status of controversy to a position where they may be judged by plain facts. What we urgently need is further work in the way of micro-petrographic analysis. I question—and it is not the first time that the doubt has been expressed—whether this kimberlite does not belong to the picrites rather than to the peridotites, that is to say, is not a volcanic rather than an

Digitized by Google

intrusive rock. The answer would furnish the key to the whole situation, and the issue, I take it, lies with the petrographer.

(4) For support of his contention that the filling of the pipes and dykes respectively was attended by radically distinct conditions, Dr. Voit relies mainly on certain structural differences, such as density of texture, minuteness of the scales of biotite, and paucity of olivine in the dyke rock, as opposed to the more porphyritic structure, the development of bunches of large-bladed biotite, and the abundance of olivine and accessory minerals in the pipe rock. I do not think it is necessary at this stage to go beyond the explanation, suggested by Dr. Voit himself but rejected by him, namely, that the texture and structure finally assumed by an eruptive rock must necessarily be influenced by the shape and size of the channel along which the erupted matter has been conveyed and in which it has solidified. We can readily understand that in the central part of a bulky magma, where cooling takes place slowly and crystallisation tranquilly, there is a tendency towards a differentiation of the individual constituents; whereas in dykes, where the proximity of the walls induces greater conduction of heat and more rapid cooling, tending to interfere with the ordinary laws of crystal separation, the result is a kind of indiscriminate crystallisation. We have experience of this in necks and dykes of felsite and basalt.

If I understand Dr. Voit's theory correctly, it means that in the kimberlite pipes the mineral constituents separated in the manner they do in ordinary saturated liquids, while in the dyke fissures separation was effected by liquation. Under these circumstances we should expect the dyke rock to be more acidic, as well as more alkaline, than the pipe rock, and I would ask Dr. Voit whether he has any evidence to that effect?

(5) Dr. Voit adopts for the diamond pipes the explanation usually given with regard to the origin of volcanic channels and vents. They are assumed to be the result of sudden and spasmodic action on the part of gases and vapours in their effort to escape towards the surface. Dr. Voit admits that these gases and vapours did eventually find an exit along pre-existing fissures, but maintains that the pipe itself terminated some unknown distance below the surface, leaving the superincumbent rock mass unaffected.

I submit that on purely dynamical grounds the latter part of his explanation is untenable. It will naturally be asked what has become of the vast mass of material which originally occupied the site of the present pipe, representing, as it does, a space a thousand feet or more in diameter, and probably miles in depth? The obvious answer is that the dislodged rock was expelled at the mouth of the channel, excepting some relatively few blocks of wall-rock that were engulfed in the ascending molten matter. It is immaterial to the argument whether the fused mass solidified before it could reach the surface, or whether it welled out in the form of lava; in the latter case it, together with the cones of agglomerate, must have succumbed to denudation. The eruption of abyssal or intrusive rocks can under no circumstances be attended with a deposition of ash or tufa, yet Mr. Carvill Lewis (who gave the name "kimberlite," and to whom we owe the earliest critical account of the structure of South

Digitized by Google

African diamond pipes), clearly distinguishes between kimberlite proper, kimberlite breccia, and kimberlite tuff, which, he says, are often indiscriminately mixed in the manner of genuine volcanic ejectmenta. All the available evidence points to the pipe being an ordinary volcanic neck and crater (the latter partly or wholly denuded), and I am inclined to think that this explanation would be more generally accepted were it not for the prejudice which the name peridotite creates in one's mind.

(6) The drift of Dr. Voit's argument, that the kimberlite magma was under great pressure both from above and from below, is evidently to show that certain factors, considered necessary for the production of diamond, were present right to the end of the eruptive act. Incidentally he maintains that iron or some ferriferous ground mass, such as olivine, is essential to the liberation of carbon in the form of diamond or graphite, apparently overlooking the fact that in Frank's experiment, which he quotes, graphite (exhibiting some abnormal properties) was obtained from calcium carbide alone. In this as well as in the other experiments referred to the *rationale* seems to be the oxidation of some metal (not necessarily iron) at the expense of a carbon oxide, and consequent reduction of the carbon, or part of it.

In Friedlander's experiment, in which graphite dissolved in olivine was transformed into diamond (without the aid of artificial pressure, as Dr. Voit supposes), it is not improbable that the determining factor is not iron carbide (Fe_3 C), but silicium carbide (Si C), the iron, accidentally present, playing no part in the process.

In the case of cast iron (Fe_5 C) + C, the diamond is, of course, derived from iron carbide (Fe_3 C). Moissan's experiment, to which Dr. Voit makes reference, proves that the requisite pressure resulted from the violent expansion of melted iron rapidly cooled.

Hannay, of Glasgow, who, as it is well known, was the first to succeed in the artificial production of diamond, fused metallic magnesium and potassium (or sodium) together with some carbon hydrates, in the form of animal and mineral fats. The mixture, retained in an iron tube hermetically closed at both ends, was heated for fourteen hours in a wind furnace. The temperature must have been considerably lower than that reached in the electric furnaces employed by Moissan and later experimenters. but this was compensated for by the immense pressure of the impounded vapours.

Mr. H. S. Harger said:—

I have read Dr. Voit's paper with considerable interest, but as I cannot agree with some of his views and statements I feel sure it will assist us to get at the truth if I place the results of my own observations before this Society.

In the first place Dr. Voit's idea that the accessory minerals in the kimberlite dykes or fissures "are very rare and of rather small size" only applies to certain fissures which might have come under his notice. There are many fissures in which the minerals are extremely plentiful (quite as much so as any of the pipes), and also very large. Out of many instances known to me I will mention for example a fissure on Secretaris, where ilmenite and garnet occur in sizes up to 2 inches' diameter and

Digitized by Google

pyroxenes 1 inch diameter. The minerals in this fissure are probably larger and more plentiful than in any pipe in South Africa except the Monastery. Next, the statement that there can be "no doubt" that the pipes are younger than the fissures is also quite incorrect as kimberlite dykes occur in the Kimberley and Premier Mines, both of which dykes are of later date than the pipes. In a general sense, however, I agree that most of the fissures, especially the big lines of fracture, are older than the pipes.

With regard to the belief that the small sized micas found in the fissures are absent from the pipe ground, I can only say my observations are quite the contrary. For example, the small micas are very conspicuous by their presence in the Lace and Voorspoed Mines, and many others. Another statement, or rather view, which I must strongly oppose relates to the origin of the minerals found in kimberlite. Dr. Voit considers that they could not have come from great depths, and asks, "Where can we find such enormous thick beds of pure garnet and mica rock?" He goes on to point out that the garnet-pyroxene boulders described recently by Dr. Corstorphine (with whom he agrees) are undoubtedly magma segregations, and that as they were formed *in situ* the diamond must, *pari passu*, have been formed *in situ* also.

His views, or rather theories, summed up, are that the eclogites found in kimberlite, as also all the garnets, ilmenite, pyroxenes, mica, diamond, etc., etc., found therein, were formed *in situ*. He says they all "no doubt" crystallised *in situ*, and he considers the suggestion that eclogites and the accessory minerals of kimberlite came from below is a "far-fetched idea." He expresses the opinion that if they had originated from below they must have been "crushed to atoms" in the ascending magma.

Now on these points I wish to join issue with Dr. Voit, not so much to prove that certain minerals and eclogites must have come from below, but to show that they did *not* crystallise where we find them to-day.

Referring in the first place to the minerals: It is well known that they are nearly always in a fragmentary state; but as Dr. Voit disagrees, I have placed on the table fragments of ilmenite, garnet, and ilmenite-enstatite rock from the Monastery and Lekkerfontein Mines, all of which are undoubted fragments. The unaided eye can distinctly see the old as well as newly-fractured surfaces, some of which still have scales of mica and fragments of oxidised mine ground adhering to their fractured surfaces, showing that they must have lain in the kimberlite in the broken state. I am sure it will be quite plain to any observer that these are broken fragments, and that most of the fractured surfaces are not fresh ones. How then can Dr. Voit say that they were formed *in situ*? I show also a piece of blue ground core from the Roberts Victor, kindly given me by Mr. G. A. Hay. In this a broken garnet can be perceived, with the blue ground still adhering to a portion of the broken face. This fragment of garnet had a kelyphite rim enclosing it on all sides, except on the broken face, and most of the kelyphite can still be seen. In the face of this evidence and the specimens shown by me at the last meeting of this Society, I fail to see how Dr. Voit can speak of far-fetched ideas

Digitized by Google

in this connection. As a matter of fact, Mr. Du Toit, of the Cape Geological Survey, who has studied the Griqualand West occurrences most carefully, is also of opinion that these minerals are included fragments which have come from below,[1] and my specimens certainly support that idea.

The suggestion by Dr. Voit that these minerals would have been smashed to atoms seems quite absurd in the face of his own admission that fragments of granite, gneiss, and crystalline schists and other exotic rocks have (as we know) survived. Even fragments of shale have survived the explosive forces; why, then, should hard minerals like garnet and ilmenite be destroyed?

Having shown that the minerals are not all formed *in situ*, I will proceed to refer to a most interesting and important specimen of garnet-pyroxene rock or eclogite from the Roberts Victor Mine. This rock is apparently of the same description as that referred to recently by Dr. Corstorphine,[2] only it differs therefrom in one most important exception. It consists primarily of emerald-green diopside and grey quartz, with calcite in the interstices. Were it not for the quartz it would coincide with Dr. Corstorphine's eclogite, in which some diamonds were found. The structure of the rock is coarsely granular, as usual, and the minerals show distinct linear banding, such as one commonly finds in crystalline schists. The garnets, though much weathered, occasionally show rough outlines of their original crystal faces. The minerals occur in bands thus: Pyroxene, garnet, quartz, garnet pyroxene, quartz. Macroscopically, the quartz looks like grey quartzite; under the microscope the quartz appears to form long, much contorted crystals, with a strong wavy extinction, giving the section a banded appearance. Taken as a whole the rock is most strongly representative of the crystalline schists, and certainly not of a magmatic concretion in an ultra-basic magma. Bearing in mind that eclogite similar to the foregoing, and coinciding with Dr. Corstorphine's diamond-bearing garnet-pyroxene rock, has been found bearing parallel grooves, suggestive of scoring, I now enquire if I have not shown much stronger evidence indicative of these eclogites being exotic boulders, than anything brought forward by either Dr. Corstorphine or Dr. Voit, that they represent magmatic segregations from kimberlite? If the evidence I have placed before you this evening, taken in conjunction with that submitted at our last meeting, cannot be satisfactorily refuted, I think some important parts of Dr. Voit's paper will require reconstruction, owing to the fact that the origin of the diamonds from his point of view is inseparably associated with the origin of the eclogite in which they were found.

There are many other points in Dr. Voit's paper with which I disagree, but I will refrain from further criticisms, as I think the fundations of his paper will have been very much shaken, unless my eclogite

---

[1] Eleventh Annual Report of the Geological Commission of the Cape of Good Hope, 1907, p. 151.

[2] "The Occurrence in Kimberlite of Garnet-pyroxene Nodules Carrying Diamonds," *Trans. Geol. Soc. S.A.*, vol. x., 1907, p. 65.

Digitized by Google

boulders and some allied specimens which have been placed before you can be satisfactorily accounted for and my statements disproved.

In view of the interest attached to the subjects dealt with in Dr. G. S. Corstorphine's and Dr. F. W. Voit's papers, it was decided to leave these open for discussion at another meeting, after which the authors would be enabled to reply; and the proceedings terminated with a vote of thanks to those who had taken part in the discussion.

Monthly Meeting, held in the Council Chamber, Chamber of Mines, Johannesburg, on Monday, 14th October, 1907, at 8.15 p.m., Dr. Geo. S. Corstorphine, Vice-President, in the chair.

The Minutes of the Ordinary Monthly Meeting, held on 9th September, 1907, were read and confirmed.

The following gentlemen were balloted for and elected Members of the Society:—Messrs. Eldred Brown, J. L. van Eyssen, and F. S. Jones.

The Chairman drew attention to an exhibit consisting of Canadian minerals, which had been presented to the Society by Mr. Ralph Stokes. He stated that this was the second contribution to the Society's Museum which the donor had forwarded during the course of his visits to the various mining centres of the world, and he begged to tender Mr. Stokes the thanks of the Society for the interest he had shown in sending the various specimens. The Chairman then read the following notes, which Mr. Stokes had written in explanation of the exhibit:—

(1) *Smaltite, probably containing some Silver, from Cobalt Silver Field, Ontario.*

(2) *Calcite, with Native Silver and Nickel "Bloom" (a product of weathering), from Cobalt.*

Digitized by Google

The rise of Cobalt, discovered in 1903, has been the most sensational feature of American mining progress for many years. To date about 250 payable veins have been found, principally characterised by smaltite, niccolite, calcite and high silver values in the form of native metal, and occasionally argentite. The bodies, averaging 4 or 5 inches, and rarely of great persistence, mostly occur as fissures in an undulating conglomerate formation, and generally cease or become impoverished upon reaching an underlying series of greenstones, porphyries and schists. Up to the middle of 1907, 14,500 tons of ore had been shipped for over £2,000,000, or about £140 per ton. It is believed that the silver was deposited later than the Cobalt and nickel arsenides, veins of which occur without the noble metal. More astounding than the minerals of Cobalt are its so-called mining companies. Many of these are sound ventures, but half of the 150 companies floated, with a joint capitalisation of £50,000,000, are mere prospects, which could not raise a carload of ore for shipment.

(3) *Specimens of Finest Asbestos, Thetford Mines, Quebec.*

(4) *Asbestos First-class Crude, worth £65 per ton, Quebec.*

(5) *Picrolite, formed abundantly in shearing planes, Thetford Asbestos Mines.*

(6) *Picrolite, formed where faulting has occurred in an Asbestos Vein.*

(7) *Small Asbestos Stringers.*

This last specimen shows a common type of rock of fair milling value. Asbestos half an inch long is the shortest recovered by the hand-cobbers. The mineral is found up to seven and eight inches in length in Quebec; also in little strings the thickness of blotting-paper. In one face in the Bell Mine, Thetford, the writer counted seventy distinct veinlets over a width of two feet.

(8) *Typical samples of Serpentine fed into Quebec Mill.*

Often a piece appearing barren yields a good percentage of the chrysotile fibre. Quebec Province now produces over 90 per cent. of the world's asbestos yield, and by far the greater portion of this is recovered by the fibreizing mills of Thetford and Black Lake. A few years ago hand-cobbing was alone practised. Old dumps of "waste" are now milled for highly profitable results. Work is performed on a large scale, for the asbestos does not occur in a single vein or series of veins, but in great masses of serpentine. The King Company's pit measures 1,100 feet by 600 feet, and is 180 feet deep. One thousand tons of rock are milled per day for about 80 tons of fibre. The usual method of treatment involves crushing in two jaw-breakers, drying, finer crushing through rolls, then pulverisation in "cyclones." These costly machines contain two revolving beaters, like heavy-bladed propellers, which are

Digitized by Google

made to rotate in opposite directions at 2,000 r.p.m. Each beater weighs 160 lbs., is of chilled iron, and lasts from 60 to 100 hours on the average. They also require frequent balancing. Though costly in repairs and power, they serve their purpose better than any impact or crushing scheme. It is desired to finely crush the rock and at the same time give the asbestos fibre a chance to get free without breaking it up. In this the machine is at fault; its action is too vigorous and smashes the fibre. Below the cyclones the pulverized product is passed over a series of shaking screens, allowing the grit and dusty asbestos to fall through and the fibre to be carried up by air suction to collectors. The fans used are commonly of 35-inch diameter, rotated according to the character of fibre to be lifted from the screen oversize. It is desirable to keep the fibres as long as possible, free from dust and grit, and white.

(9) *Asbestos Fibre, value* £12 13*s*. (*virtually the best produced*).

(10) *Asbestos Fibre, value* £7 8*s*.

(10*a*) *Asbestos Fibre, value* £5 6*s*.

(11) *Nickel bearing Pyrrhotite and Chalcopyrite from the Creighton Mine, Sudbury, Ontario, which yields over half the World's Nickel.*

The nickel, as pentlandite, is rarely discernible. According to Government geologists, the sulphides "settled out" from associated sheet of quartz-norite, as matte from slag, in response to laws of specific gravity and mutual attraction. This hypothesis is forcibly attacked by the advocates of the aqueous theory, who only recognise the influence of replacement along planes of water circulation.

The following contribution to the discussion on Dr. F. W. Voit's paper "On the Origin of Diamonds" was read by the Secretary in the absence of the writer, Mr. A. J. R. Atkin :—

Referring to Dr. Voit's paper, the question of the origin of the diamonds in the pipe seems to me to be bound up with the problem of the source of the eclogite masses found in the pipes, since the occurrence of diamonds in them is now confirmed. Messrs. Johnson and Harger have, in my opinion, established their contention that the eclogite masses as now found are true boulders, and this is in accordance with my own observations. Mr. Harger considers the eclogite masses to be fragments of a deep-seated formation, while Mr. Johnson is uncertain whether they are originally portions of such, or whether they entered the pipes as a molten rock, which was smashed up after cooling. Drs. Corstorphine and Voit, on the other hand, consider them to be segregations formed in the pipe, and that they owe their rounded shape to that cause, and not to attrition in the pipe. A careful examination of a large number of these boulders should surely definitely settle this important question, and I would suggest that those numerous members who have the opportunity

Digitized by Google

be invited to investigate this matter and lay their conclusions before this Society.

The Secretary also submitted the following reply, sent by Mr. P. A. Wagner, who was absent in Europe, to the discussion on his paper entitled "Petrological Notes on Rocks in the Vicinity of Craighall" (read 25th February, 1907):—

In my paper of the 25th of February I particularly emphasised that the only primary muscovite in the granite under consideration occurred as a parallel intergrowth with biotite.

As the section was perpendicular to the basal cleavage, I cannot say whether it was merely a bleached portion of the biotite, but consider this to be extremely unlikely, as the line of demarcation was perfectly sharp, and the biotite nowhere else showed this tendency. I may say that I am also acquainted with a bleached biotite in the kimberlite, and can assure Professor Schwarz that it is totally different from that under consideration.

A paper entitled "On the Supposed Kimberlite Magma and Eclogite Concretions," by Professor T. G. Bonney, Sc.D., F.R.S., etc. (hon. member), was read on behalf of the author by Dr. Corstorphine.

Dr. F. W. Voit read a paper entitled "Further Remarks on the Kimberlite Rock and the Origin of Diamonds."

Messrs. H. S. Harger and M. Weber took part in the discussion on this paper.

A paper entitled "On the Origin of River Diamonds within the Area of the Vaal," by Mr. Hans Merensky, was read on behalf of the author by Dr. Corstorphine.

Messrs. H. S. Harger and F. W. Voit took part in the discussion on this paper, and the Meeting terminated with a vote of thanks to the various authors for their contributions.

Digitized by Google

Monthly Meeting held in the Council Chamber, Chamber of Mines, Johannesburg, on Tuesday, 17th December, 1907, at 8.15 p.m., Dr. Geo. S. Corstorphine, Vice-President, in the chair.

The Minutes of the Ordinary Monthly Meeting, held on 14th October, 1907, were read and confirmed.

The following gentlemen were balloted for and elected members of the Society:—Messrs. Henry Martin and P. Holyoake Ross.

The Chairman drew the attention of members to the fact that the South African Association for the Advancement of Science proposed holding its annual meeting at Grahamstown next year, and that Professor E. H. L. Schwarz, of the Rhodes University College, Grahamstown, who was President of Section B, was arranging various geological excursions to interesting places in the Eastern Province. Members who contemplated attending the meeting should communicate either direct with Professor Schwarz or send their names to the Secretary of the Society.

Dr. G. S. Corstorphine discussed Mr. Hans Merensky's paper "On the Origin of River Diamonds within the area of the Vaal." He said:—

Regarding Mr. Merensky's query as to the diamonds of Somabula in Rhodesia, I think the evidence there points to the diamonds and other gem stones being derived from pegmatite veins in the granite. There is a certain amount of alluvial material, partly granite *débris*, partly laterite, in which the diamonds also occur. The interesting feature, however, is the fact that diamonds are obtained from masses of weathered granite throughout which the quartz and felspar of pegmatite veins still remain *in situ*. There is certainly little resemblance between the high quality of an unsorted lot of Somabula stones and the mixed stuff obtained from even the best pipes. The Somabula stones which I saw were mostly octahedra of a slightly greenish colour, macles were fairly common, but there was no brown or yellowish rubbish, nor did I see any splintered stones.

The minerals associated with the diamonds at Somabula are typical of a granite and schist contact, comprising varieties of corundum, chrysoberyl, rutile, staurolite and tourmaline.

Messrs. A. von Dessauer, H. S. Harger, and J. H. Ronaldson also took part in the discussion.

Digitized by Google

Replying to the discussion on his paper entitled "The occurrence in Kimberlite of garnet-pyroxene nodules, carrying Diamonds," Dr. Geo. S. Corstorphine said:—

The prolonged discussion which has arisen over my short paper on "The occurrence in Kimberlite of garnet-pyroxene nodules carrying Diamonds," is at once evidence of the perennial interest which the diamond excites, and of the difficulties met in trying to discover the conditions under which it has originated in nature.

In replying for my own side of the controversy, I shall first deal with certain minor details.

Regarding my statement that no mass or sheet of eclogite is known in South Africa, Mr. Harger mentioned that Mr. M. E. Frames had found an outcrop in Griqualand West. I asked Mr. Frames about this, and he informed me that some years ago a Mr. Cox brought him a rounded piece of eclogite from the Prieska neighbourhood, which he thought must be the specimen referred to by Mr. Harger. I think it probable that this specimen weathered out of a Kimberlite intrusion since there are pipes and fissures in the district, and no confirmation of an eclogite outcrop has been obtained by the Cape survey. The occurrence of eclogite in South Africa, outside of the diamond mines, is therefore not substantiated by the specimen which came into Mr. Frames' hands.

Professor Bonney in his paper deals with the same question, and rightly says that what admittedly is a negative argument may any day be demolished. On the other hand, we have in this country probably the most extensive development of conglomerates in the world—there are conglomerate bands, often hundreds of feet thick, in the Cape Colony and in the Transvaal in every formation from the oldest sediments to the youngest, representing the wear and tear of vast masses of pre-existent rocks. These conglomerates are distributed over an enormous area. In them we are able to identify boulders from each of the older series, in many cases including rocks of comparatively limited distribution. Now, were eclogite such a common and wide-spread massive rock as must be the case if the pieces in the diamond mines of the Cape, the Orange River, and Transvaal Colonies, came originally from underlying sheets or bosses, belonging, as those who hold this view apparently mean, to one of the oldest South African formations, surely we might reasonably expect to have found, if not by this time its outcrop among the old schists, still, at least, boulders of it in one or other of the many conglomerates, and not have the fragments confined to the diamond mines. All undoubted boulders found in a diamond mine are referable to rocks which are either exposed in the neighbourhood, or which, from the geology of the country, we know are certain to occur at unopened depths. Only the types akin to Kimberlite itself are not known outside of the pipes.

Even if, sooner or later, we should find an eclogite in one of the older formations, it will have to be a diamantiferous one before it can be allowed any weight in settling the present controversy.

Professor Bonney makes an error in assigning to me certain views expressed by Dr. Voit with reference to the absence of any sign of attri-

Digitized by Google

tion on diamonds from Kimberlite, and the inferences to be made therefrom. As will be shown later, I am not at one with Dr. Voit as regards the formation of the diamantiferous breccia. Further, in a footnote, Professor Bonney remarks that incidentally I with Dr. Voit appear to repudiate "cup and ball" action in the pipes. I do not know that I should so describe the movements that affected the rock in a diamond-bearing pipe during the processes which produced brecciation, but no one can have paid even slight attention to the appearance presented by a pipe breccia *in situ*, without being impressed by the evidence that prolonged motion of varying degrees of intensity must have occurred. For instance, one finds pieces of the wall of the pipe right in the middle of the diamond-bearing contents, and masses of once overlying rock—like the Waterberg conglomerate of the Premier mine, a formation long ago denuded from the vicinity—may occur in the breccia. Again, almost every mine when well opened out shows different types of Kimberlite, and fragments of one type may be found as inclusions in another. There have certainly been several intrusions affecting the pipe material in every individual mine which we know in South Africa. Further, there must have been prolonged action, probably akin to that in a mud volcano or in a geyser, after the initial explosion or explosions which produced the vent. Such movement would not necessarily be the same, nor occur at the same time, throughout the pipe.

Professor Bonney corrects my statement as to his view of the mother rock of the diamond. Naturally I accept his interpretation of his previous papers. He wishes to leave open the question whether the diamond originated in an eclogite magma or in some earlier more basic one which, with the addition of acid material, subsequently became eclogite. My own view is that the "eclogite" is a direct product of the magma in which the diamond was produced.

I turn now to the main question in dispute—are the aggregates of garnet and pyroxene nodules or boulders?

To make clearer the view which I take of the origin of the garnet-pyroxene masses, I shall briefly explain what I consider to be the mode of origin of the Kimberlite of the diamond pipes.

I have never had any hesitation in classifying the characteristic South African Yellow and Blue Ground of the diamond pipes as breccia, and if I often apply Carvill Lewis' name "Kimberlite" to it, I do so not in his sense of a massive igneous rock, but simply, in accord with Professor Bonney's own suggestion, as a convenient and distinctive term for so characteristic and interesting a breccia.

The occurrence of this breccia to-day is exactly the same as that of numerous others, such, for instance, as the basic tuffs which fill many of the necks penetrating the Carboniferous sediments of Fife and the Lothians. The only difference is that in no case have we found evidence of lavas having flowed from the diamantiferous pipes, and there was never, so far as we know, an ejection of the breccia. I do not follow Professor Bonney in his statement that Kimberlite is not a magma. Of course not, but the breccia must have originated from an igneous magma,

Digitized by Google

and to this magma I refer all the material found in the pipes, other than that which has been derived from the rocks now, or formerly, bounding them.

From this magma the diamond itself crystallised and with it the ilmenite, diopside, garnet, zircon, and all the other minerals not due to secondary processes, nor derived from the rocks surrounding the pipes. The minerals we regard as typical of blue ground were the constituents of the deep-seated rock which solidified from the magma, and I have never meant that the diamond, any more than the other minerals, was confined to the segregation nodules or veins which may have formed.

The precise character of the magma as it solidified in depth we do not know, but it must have resembled other deep-seated peridotites. In it there were coarser and finer grained portions; aggregates of one or more of the constituent minerals; segregation nodules and segregation veins—all these being represented in the breccia.

Examples of the diversely grained original peridotite, or pyroxenite as the case may be, are most distinctly approached in the so-called "hardibank" of the different mines. Aggregates of garnets, of ilmenite, and of diopside are by no means uncommon—there is, for instance, exhibited in the South African Museum, Cape Town, a nodule from Jagersfontein, consisting entirely of garnet, and I have seen similar masses in the Monastery Mine. Segregation nodules are, as I hold, illustrated by the Roberts Victor specimen, the description of which raised this present discussion, and by those described by Professor Bonney and Professor Beck, from Newlands. I cannot do more than repeat that to my mind the related yet divergent composition of any suite of such specimens is a very strong argument for their origin as segregations. Objection has been raised that in addition to rounded nodules there are many "eclogites" more or less flat and somewnat angular in form. These, according to my view, are simply the broken pieces of what originally were segregation veins, and that such were present we can have no better proof than the beautiful pegmatite of diopside and ilmenite common in the Monastery Mine. This rock is found in fragments only, generally angular, but sometimes slightly rounded, and can only be derived from a vein in the rock to whose shattering the breccia is due.

After the peridotite had, at some considerable depth beneath the earth's surface, crystallised to a greater or less extent, the explosions which formed the pipes or necks in which the breccia is now found, must have occurred, and after the first series of violent explosions which formed the vent, I picture a long continued series of probably steam explosions gradually decreasing in intensity. These produced a mass probably resembling, as I have said, the contents of a mud volcano or of a geyser. The action which went on in the pipe fractured and comminuted much of the material, separated the various minerals from one another, and in numerous instances broke up the individual crystals, whether of diamond, garnet, diopside or other characteristic constituent. It mas most probably during this secondary stage that the fragments from the walls got incorporated in the breccia and that the decomposition, or partial decom-

Digitized by Google

position, of much of the material occurred. Where less penetrated by steam during this period, and less churned about, the rock remains to-day as "hardibank," whereas the portions of the pipe-contents most affected were altered or decomposed, and brought into such a condition that the subsequent percolation of surface and underground water could produce the alteration so generally present.

The nodules of eclogite, when individually separated from the rock enclosing them, shared in the movement, but I am of the opinion stated in my paper, that their shape as we now find them, is due essentially to their concretionary origin, and not to any movement they may have undergone. The appearance of striation in certain of the tabular specimens is owing to the original banded arrangement of the constituent minerals and the corrosion which took place subsequently. At the same time some of the nodules, and the broken pieces of the segregation veins, underwent a small amount of attrition during the movement in the pipe.

Summarising the position, I hold that the garnet-pyroxene nodules and the related fragments derived from veins, with or without diamonds, have been produced by a process of differentiation from the magma from which the Kimberlite originally solidified, my reasons being:—

1. The fact that the nodules consist almost entirely of minerals so characteristic of "blue ground," as diopside and garnet;
2. The occasional presence of the diamond;
3. The limits of the mineral variation and the varying proportions in which the constituent minerals are present;
4. The occurrence of pegmatitic structure in certain nodules.

Others hold that the "eclogite" masses are true boulders, and have come into the Kimberlite in the same way as the pieces of sandstone, diabase, and other rocks derived at various depths from the walls of the pipes. According to that view the eclogite is an accidental constituent, but yet in the opinion of some of the parties to this discussion, it is the one to which the essential interest of Kimberlite—the presence of the diamond—is due.

A reply was submitted on behalf of Dr. F. W. Voit to the discussion on his papers entitled "Kimberlite Dykes and Pipes" and "The Origin of Diamonds."

Dr. Voit's reply was as follows:—

In discussing my paper Mr. von Dessauer said that he could not understand where the enormous masses of rock had been removed to, to make room for the pipe matter if the pipes were conical batholites. He makes some calculations of several pipes down to 5,000 feet, which for the greater part are just opened on the surface and we know nothing about their character in depth. He does not say how he arrives at his figures, as he does not give the size of the mines at the surface, their contraction say at 1,000 and 2,000 down to 5,000 feet which would of course be rather a difficult matter. He does not make any remarks about the possible shape of the mine at greater depths. He allows only 10 per cent. of foreign rock frag-

Digitized by Google

ments, though it is well known that this figure is far too low with regard to, for instance, the Lace Mine. In fact we have mines where the foreign rock fragments amount to 50 per cent. and more.

If Mr. von Dessauer intends to furnish data I would suggest that he take as an example the Kimberley mine which is worked down to nearly 3,000 feet. He would then see that the explosion theory does not stand particularly in the way of a batholitic origin.

The Kimberley mine was some 1,100 claims at the surface, its contraction in the first few hundred feet, where it takes a round shape, was very considerable, and from about a thousand feet the vent, relatively speaking, was a very narrow one.

Mr. von Dessauer says that he does not understand how a few feet of shale or basalt could remain intact in their original position over a crater emitting such enormous masses of removed rock. I have not stated that the removed rock was emitted, and I should like Mr. von Dessauer to show me where I spoke of a few feet of shale or basalt as a roof. If he will read my paper carefully he will see that I speak of a roof of enormous thickness. Thousands and thousands of feet of the younger portion of the Karroo formations may have covered these vents and have been removed by erosion during the lapse of millions of years since the formation of the pipes.

With regard to the question as to where the mass removed by a laccolite has been transferred, I refer Mr. von Dessauer to the text books of geology, and he will see that the question of the mode of origin and the results of the intrusion of laccolite and similar intratelluric intrusions of a magma in domes is one of the most difficult problems in geology.

Michel-Levy and Suess think that the greater part of a rock which originally took the place of a laccolite was resorbed by the extruding rock, and was simply "assimilated." Doelter says that batholites have not incorporated the country rock, at least not in their upper parts, close to the roof, but elevated the overlying parts forming them into an anticline like an enormous watch glass. Brögger says that the intrusion took place in a merely mechanical way; the overlying part was elevated, and the magma forced into the formation while the walls of the vent were squeezed into folds. To a certain extent the replaced country rock has, no doubt, been incorporated by the Kimberlite magma, for the greater part, however, this replacement took place, I think, in a purely mechanical way. We know that the formations round the mines are *dipping away* from the pipes in all directions; the strata along the edges of the pipe are turned up; a parallel to the Pretoria formation in the case of our large Bushveld granitic batholites; here the Pretoria shales dip away from the granite on all sides just as the peripheral parts of a watch glass do from the centre.

Contrary to this phenomenon, we know that in volcanic necks the strata dip *towards* the axis of the pipe. The country rock round the pipes is sometimes tilted up vertically, as can be observed at the small pipes on Spytfontein. The shales and sandstones, through which the main shaft of the Kimberley mine was sunk, are tilted to high angles, and show much

Digitized by Google

evidence of pressure, a very strong point, as otherwise the generally flat Karroo formation is very little disturbed.

It is generally admitted that the mode of origin and results on the intruded strata of laccolites and similar intratelluric magmatic intrusions up to the present have not yet been explained satisfactorily, still, however, this theory of a rock taking the place of a removed mass of formation, lifting up part of it and squeezing it into folds on the walls, would be more plausible in reference to such small vents as the pipes than in the case of enormous granitic batholites.

ECLOGITE SEGREGATIONS.

With regard to the much disputed character of the eclogite nodules, I should like to make the following remarks.

From all sides, and especially from Mr. Bonney and Mr. Harger, the rounded faces of all the "Eclogites and similar boulders" have been taken as the stumbling block to the segregation theory.

Mr. Bonney says that Dr. Corstorphine and myself tacitly repudiate the rounding of these eclogite and similar boulders by a sort of "cup and ball" action in a volcanic pipe. I must say that I always considered the term "cup and ball" action extremely ill chosen, as I think that nothing of the sort happened. I rather think the rounded nature of foreign rock fragments is simply due to the dissolving capacity of the Kimberlite magma which has eaten away the corners and left a more rounded fragment. Certainly, however, neither Dr. Corstorphine nor myself ever repudiated the rounded character of the Eclogites, on the contrary, I always maintained that the characteristic of segregations of a magma is their rounded shape, and we must not forget that the phenomena which may be produced as contact metamorphism on a foreign rock fragment included in a magma, can also be found on segregations. From the very many eclogite segregations which I saw I brought some specimens from the Lovedale mine before this Society with the enclosing blue ground, and it is accepted that these cannot be anything else than segregations. In the Lovedale blue ground, which I have previously described, a finely grained rock with porphyritic diopside, very many coarsely grained eclogites are found; the hardness of these eclogites varies, and I have brought before the Society those which are even much softer than the enclosing blue ground. The chemical composition of the nodule and its matrix is absolutely the same, in both cases a diopside rock with more or less garnet, still, however, we have that very same smooth and absolutely rounded surface which Bonney perhaps would call waterworn and ellipsoidal, or round balls of these nodules to which the term "cup and ball action" might be very well applied, exist in the mine, and, where they are still imbedded in the ordinary finely grained blue ground, their sharp contours can be seen; the contact of nodules and matrix is extraordinarily abrupt and well marked. Sometimes these eclogitic nodules show absolutely ideal contacts as we generally only observe it at the foreign rock inclusions of the Kimberlite magma. In the best specimen I laid

Digitized by Google

before the Society we have the same coarsely crystalline rock, a true eclogite, in a very finely grained blue ground which shows absolutely the same composition with perhaps fewer garnets. The material of matrix and inclusion is absolutely identical. But the nodules show a ring $\frac{1}{8}$ of an inch thick of very finely grained material, and it appears as if the eclogite nodule, which is only a coarsely grained variety of the Kimberlite it is imbedded in, had been included as a rock fragment in an eruptive magma and thus undergone contact-metamorphism, a splendid parallel to the rounded and zoned inclusions of exotic rock fragments. All the phenomena of contact-metamorphism we see then repeated in specimens of blue ground which are accepted as indubitable segregations. I will not deny that occasionally an eclogite may be an exotic rock and may have been brought up by the ascending magma, as especially certain banded eclogites with pink garnets are probably exotic rock fragments; by far the greater and indeed overwhelming number, however, of all the eclogites and similar rocks are certainly segregations.

SERPENTINIZATION.

Before concluding I wish to make some remarks about the alteration of the kimberlite. This point has been recorded by Lewis, and Du Toit[1] in his excellent essay referred to above. I think, however, that up to the present too little attention has been given to that point. Du Toit calculates that the increase in bulk of the material in passing into the stage which we know as blue ground will be something like 13½ per cent.; in fact it will be higher, as the original mineral which built up the rock, is in most cases probably diopside. Covered as the pipes were, the pipe material during its serpentinization could not extend anywhere, and it is clear that the breaking effect due to an increase in volume must have been considerable.

That effect of pressure we can observe under the microscope beautifully, and we can safely say the more decomposed the kimberlite is, the more its phenocrysts are bent and broken. I think, however, that this expansive force, which did not find an outlet, must also have had an effect on the large crystals of the accessory minerals which were broken, and here we may find an explanation for the broken diamonds.

Regarding these broken diamonds Gardner Williams says: "The frequent occurrence of broken diamonds imbedded in hard Kimberlite is a conclusive proof that the diamonds do not occur in their original place of crystallisation," and he says further that Nature never produced anything incomplete. Here Mr. Gardner Williams is certainly wrong, for we know that only very few minerals are crystallised perfectly. I personally think that these so-called splinters are nothing but incomplete forms of crystallisation, but still I should not like to give a definite opinion about it. Certainly I am not so sure about the Cullinan being a broken diamond. It may have lain against a boulder and the growing of the crystal could only take place towards certain directions on a

[1] Eleventh Annual Report of the Geol. Comm. of the Cape of Good Hope, 1906.

Digitized by Google

certain number of faces. Still, I saw indubitable splinters myself, and I think it is possible that some diamonds, if not broken in mining or during the washing process, may have been broken in the blue ground itself either by the secondary magmatic and pneumatic extrusions during and after the formation of the pipe, or by the pressure during serpentinization. We know that the diamond is very brittle and cracks very easily if only a slight pressure or blow is exercised.

Whether it is true or not that diamonds explode when brought to the surface, I do not know.

Crookes and Gardner Williams state that this is the case, and the latter says that this cracking is more due to the result of heat or drying than to the tension of inward pressure. If this exploding of diamonds really happens, then, I think, we may have to do with a displacement of the molecular arrangement due to a change in temperature very similar to the leucite phenomenon.

Generally the system of crystallization of the leucite is considered to be isometric. The isometric molecular arrangement, at least of the larger crystals, cannot exist however for the temperature and pressure at the earth's surface. Hence molecular displacement takes place, giving rise to a more or less complicated apparent twinning, and optical anomalies are noticed. The isometric character returns if the section is heated to 500 degrees Celsius (Rosenbusch).

A similar displacement of the molecular arrangement in the diamond may take place during the cooling of the magma.

Certainly, if really broken diamonds exist in such quantities as certain people maintain, we have more than one sound explanation for this phenomenon, and we need not look out for such a far fetched idea, as that the diamonds, formed at an unknown depth, were separated from their original matrix and brought into the pipe by volcanic action, through which they were more or less broken.

We do not know of any minerals formed at unknown depths and brought to the surface by volcanic action. Why should we assume such an unusual genesis for the diamond?

The Chairman, on behalf of the author, Mr. J. P. Johnson, read a paper entitled "The Tin Molybdenum and Lead Occurrences near Potgietersrust." Before doing so, however, he referred to a telegram which had been sent by the President of the Society requesting his protest in the name of the owners of Appingendam Claims being entered against Mr. Johnson describing the molybdenum and cassiterite deposits on Appingendam. The Chairman stated that he had already looked through Mr. Johnson's paper and as he did not think there was anything in it to which exception could be taken by the owners of Appingendam he felt justified in reading it. The President had not seen the paper and had doubtless wished to prevent the Society having even the appearance of passing judgment on the merits of private prospecting ventures.

The meeting terminated with a vote of thanks to the various authors for their contributions.

Digitized by Google

INDEX OF MINUTES OF PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF SOUTH AFRICA.

1907.—Pages i.-lxviii.

	Pages
Anniversary Address of President, Dr. Geo. S. Corstorphine -	xix.-xxvii.
Annual General Meeting, Eleventh - - - - - -	i.-xxviii.
Annual Report of Council, 1906 - - - - - - -	i.-xviii.
Alteration of Rules of Society - - - - -	xxix.-xxxi.-xxxiv.
Atkin, A. J. R. Discussion on F. W. Voit's paper on "The Origin of Diamonds" - - - - - - - - - - - -	lviii.
Broom, R. Remarks on Fossil Bones from Northern Transvaal -	xxxiv.
Bowker, J. Mitford. Fossil Bones from farm Wiepe, N. Transvaal, sent by him - - - - - - - - - - -	xxxiv.
Canadian Minerals - - - - - - - - - - - -	lvi.
Cobalt Lodes of Balmoral, The, by *Prof. R. Beck, of Freiberg* - (Translated and Communicated by A. von Dessauer.)	xxx.
Council, Election of, for 1907 - - - - - - - - -	xxvii.
Corstorphine, Geo. S. Discussion on H. Merensky's paper on "The Origin of Diamonds within the Area of the Vaal -	lx.
Dessauer, A. von. Discussion on F. W. Voit's paper on "Kimberlite Dykes and Pipes" - - - - - - - - - -	xlviii.
Donations to Library - - - - - - - - - - -	ii.-vi.
——— Museum - - - - - - - - - -	vi.-vii.
Draper Medal - - - - - - - - - - - -	viii.-xxix.-xxx.
Exchanges, Library - - - - - - - - - - - -	iii.-vi.
Financial Statement for year 1906 - - - - - - -	x.
Fossil Bones from Northern Transvaal - - - - - - -	xxxiv.
——— Remarks on, by *E. Jorisen* - - - - - - -	xxxvi.
Further Remarks on the Kimberlite Rock and the Origin of Diamonds by *F. W. Voit* - - - - - - - - - -	lix.

Digitized by Google

Pages

Geological Aspects of South African Scenery (Anniversary Address of President), by *Geo. S. Corstorphine* - - - - - - xix.
Geological Structure of the Middelberg District, with Special Reference to the Character, Relationships, and Thickness of the Waterberg System, by *E. T. Mellor* - - - - - - xxxiii.
Gneiss Formation in Africa, by *F. W. Voit* - - - - - - xlvi.
Gold-bearing Rock of the Ayrshire Mine, Lomagundi, by *Prof. R. Beck*, of Freiberg - - - - - - - - - - xxx.
(Translated and communicated by A. von Dessauer.)
——— Discussion on, by *C. B. Kingston* - - - - - - xxx.
——— Discussion on, by *F. P. Mennell* - - - - - - xxxii.

Harger, H. S. Discussion on Geo. S. Corstorphine's paper, "The Occurrence in Kimberlite of Garnet-pyroxene Nodules, carrying Diamonds" - - - - - - - - - - - xxxvii.
——— Discussion on F. W. Voit's paper on "Kimberlite Dykes and Pipes" - - - - - - - - - - - - liii.
Honorary Auditor, 1907 - - - - - - - - - - - xxviii.
Honorary Members, 1906 - - - - - - - - - - xi.
Honorary Secretary and Treasurer, 1907 - - - - - - xxviii.

Jorissen, E. Discussion on H. Kynaston's paper, "Note on the Correlation of the Bushveld Sandstone Series and Overlying Volcanic Rocks" - - - - - - - - - - xxxvi.
——— Remarks on the Discovery of Fossil Bones in Northern Transvaal - - - - - - - - - - - - xxxvi.

Karroo Fossil Reptilia - - - - - - - - - - xxxv.
Kimberlite Dykes and Pipes, by *F. W. Voit* - - - - - - xxxvii.
——— Discussion on, by *C. Sandberg* - - - - - - xliv.
——— Discussion on, by *A. von Dessauer* - - - - - - xlviii.
——— Discussion on, by *H. L. Krause* - - - - - - xlix.
——— Discussion on, by *H. S. Harger* - - - - - - liii.
——— Reply to discussion, by *F. W. Voit* - - - - - - xliv.
Kingston, C. B. Discussion on Prof. Beck's Paper on "Gold-bearing Rock of the Ayrshire Mine, Lomagundi" - - - xxx.
Krause, H. L. Discussion on F. W. Voit's Paper on "Kimberlite Dykes and Pipes" - - - - - - - - - - - - xlix.

Library - - - - - - - - - - - - - - ii.
——— Remarks on position of, by *Geo. S. Corstorphine* - - xviii.
——— Donation to - - - - - - - - - - - ii.
List of Honorary Members, 1906 - - - - - - - - - xi.
——— Members, 1906 - - - - - - - - - - xii.-xviii.

Marginal Phenomena and Geological Relations of the Granite North of Johannesburg, by *H. Kynaston* - - - - - xxxiv.
Mennell, F. P. Discussion on Prof. R. Beck's Paper on "Gold-bearing Rock of the Ayrshire Mine, Lomagundi" - - - - xxxii.
Membership - - - - - - - - - - - - - - i.
Members, List of - - - - - - - - - - - - - xii.-xviii.
Monthly Meetings, 1906 - - - - - - - - - - - - i.
Monthly Meeting, February, 1907 - - - - - - - - - - xxix.
March - - - - - - - - - - xxix.
May - - - - - - - - - - xxxi.
June - - - - - - - - - - xxxiv.
July - - - - - - - - - - xxxvi.
August - - - - - - - - - - xxxvii.
September - - - - - - - - - - xlvii.
October - - - - - - - - - - lvi.
December - - - - - - - - - - lx.
Museum, Report of Committee - - - - - - - - - vi.
——— Remarks on position of, by *Geo. S. Corstorphine* - - xviii.

Digitized by Google

Pages

New Members - - - xxx., xxxi., xxxiv., xxxvii, xlvii., lvi., lx.
New Papers read, 1906 - - - - - - - - - - - - vii.
Note on the Alteration of the Felspars in the Felspathic Quartzite underlying the Hospital Hill Slates, by *R. B. Young* - - xxxiv.
Notes on the Auriferous Conglomerates of the Witwatersrand, by *R. B. Young* - - - - - - - - - - - - xxxi.
Note on the Correlation of the Bushveld Sandstone Series and Overlying Volcanic Rocks, by *H. Kynaston* - - - - xxxiii.
——— Discussion on, by *E. Jorissen* - - - - - - - xxxvi.
Note on the "Field Relations of the Transvaal Cobalt Lodes," by *E. T. Mellor* - - - - - - - - - - - - xxxiii.
Note on "Lherzoite and Eclogite Boulders from the Roberts Victor Mine," by *J. P. Johnson* - - - - - - - xlvi.

Occurrence in Kimberlite of Garnet-pyroxene Nodules carrying Diamonds, by *Geo. S. Corstorphine* - - - - - - xxxv.
——— Discussion by *H. S. Harger* - - - - - - - xxxvii.
———Discussion by *E. H. L. Schwarz* - - - - - - - xlvii.
——— Reply to Discussion by *Geo. S. Corstorphine* - - lxi.
On a Collection of Permo-Carboniferous Plants from the St. Lucia (Somkele) Coalfield, Zululand, and from Newcastle District, Natal, by *A. C. Seward* - - - - - - - - - xlvi.
On the Origin of River Diamonds within the area of the Vaal, by Hans Merensky - - - - - - - - - - - lix.
——— Discussion on, by *Geo. S. Corstorphine* - - - - lx.
On the supposed Kimberlite Magma and Eclogite Concretions, by *T. G. Bonney* - - - - - - - - - - - - lix.
Origin of Diamonds, The, by *F. W. Voit* - - - - - - xxxvii.
——— Discussion on, by *A. J. R. Aitken* - - - - - lviii.
——— Reply to Discussion, by *F. W. Voit* - - - - - lxiv.

Petrographical Note on Kimberley Slates in the Eastern Rand, by *J. McClelland Henderson* - - - - - - - - - xxix.
Petrological Notes on Rocks in the Vicinity of Craighall, by *P. A. Wagner* - - - - - - - - - - - - xxix.
——— Discussion on, by *E. H. L. Schwarz* - - - - - xxxii.
——— Reply to Discussion, by *P. A. Wagner* - - - - - lix.
Presentation of Specimens of Diamond bearing Breccia to Museum by Mr. J. P. Johnson - - - - - - - - xxx.
Presidents, List of Past - - - - - - - - - - - - xi.
President, 1907 - - - - - - - - - - - - - xxvii.

Sandberg, C. Discussion on F. W. Voit's Paper on "Kimberlite Dykes and Pipes" - - - - - - - - - - - - xliv.
Schwarz, E. H. L. Discussion on P. A. Wagner's Paper, "Petrological Notes on Rocks in the Vicinity of Craighall" - - xxxii
——— Discussion on Geo. S. Corstorphine's Paper, "The Occurrence in Kimberlite of Garnet-pyroxene Nodules, carrying Diamonds - - - - - - - - - - - - - - xlvii.
Secretaries, List of Past Honorary - - - - - - - - xi.
South African Association for the Advancement of Science, Annual Meeting, 1908 - - - - - - - - - - - - - lx.
Statement of Revenue and Expenditure, 1906 - - - - - x.
Stokes, Ralph. Remarks on Specimens of Canadian Minerals presented by him to Society's Museum - - - - - - lvi.

Tin, Molybdenum and Lead Occurrences near Potgietersrust, The, by *J. P. Johnson* - - - - - - - - - - - lxviii.

Vice-Presidents, 1907 - - - - - - - - - - - - xxviii.

Digitized by Google

Digitized by Google

Publications of the Geological Society of South Africa.

The under-mentioned publications can be purchased at the Office of the Society at the following prices:—

Annual Transactions ...	£2	0	0	to	£2	5	0
Quarterly Parts					0	15	0
Half-Yearly Parts					1	1	0
Monthly Parts (of certain old volumes) ...					0	2	6

There is a reduction of fifty per cent. on the above prices to Members.

OUT OF PRINT—Vols. I. and V.;
Vol. II.; Parts 1 and 2.

Anyone possessing these volumes and parts of volumes that are out of print, and wishing to dispose of them, should communicate with the Assistant Secretary.

The Transactions may be obtained from Messrs. Wm. Wesley & Son, 28, Essex Street, Strand, London, W.C., who are the Society's European Agents.

Digitized by Google

Digitized by Google

Figure 1

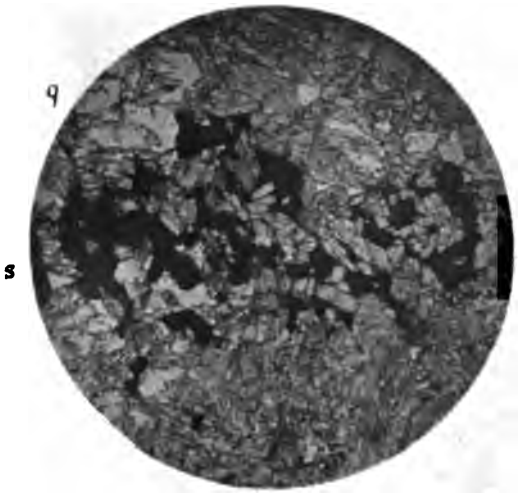
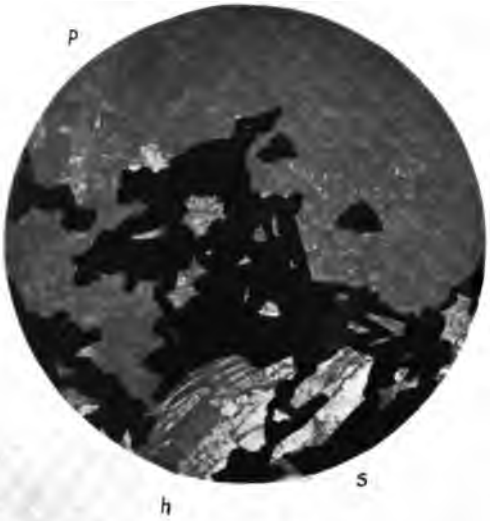


Figure 2



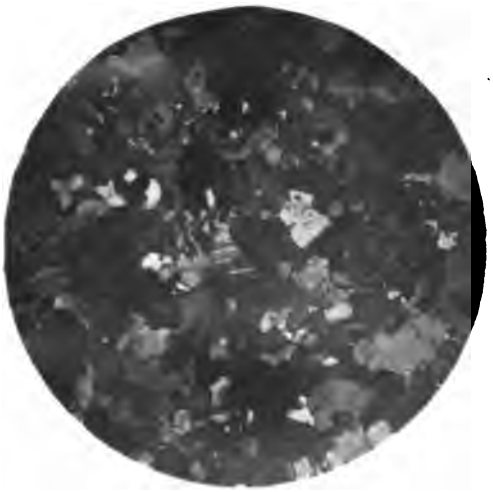


Figure 3

Figure 4

Digitized by Google

Digitized by Google

Figure 1

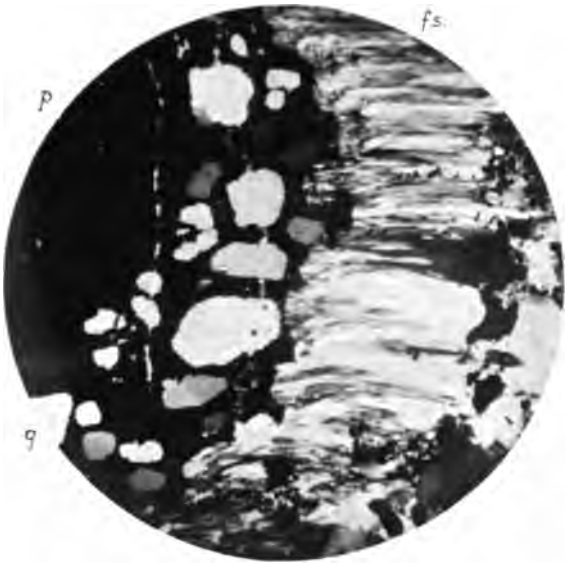
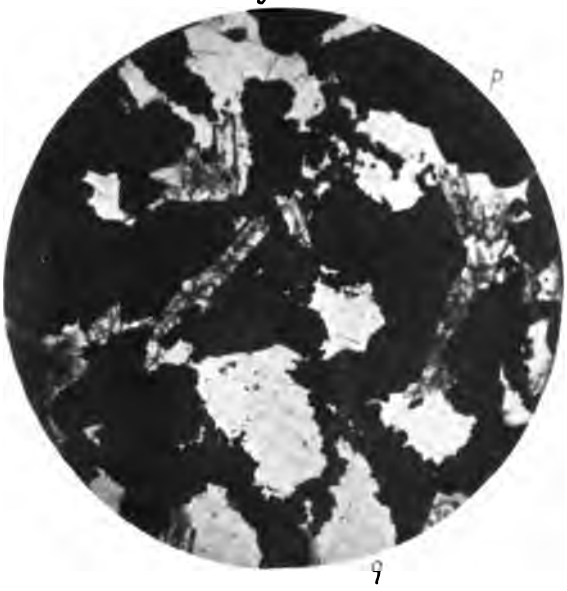


Figure 2



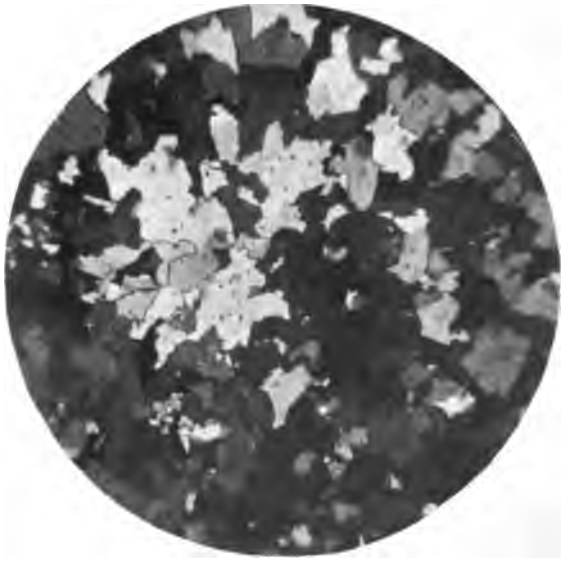


Figure 3

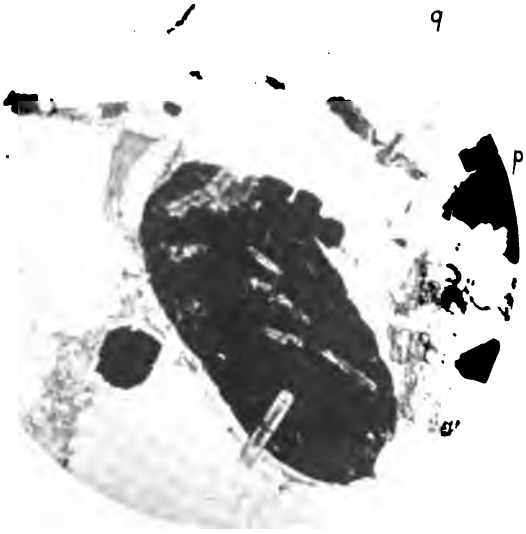


Figure 4

Digitized by Google

Digitized by Google

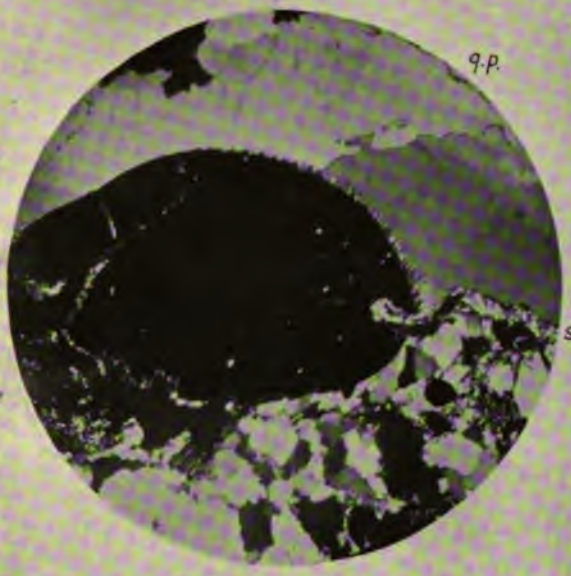


Figure 5

Figure 6

Figure 7

Figure 8

Digitized by Google

Digitized by Google

Figure 9

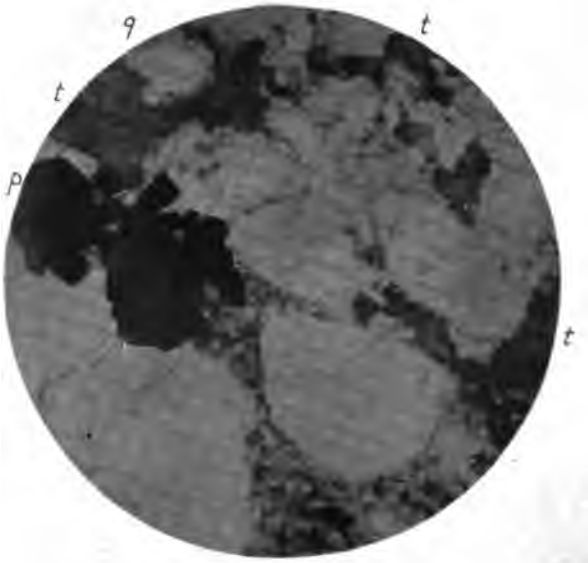
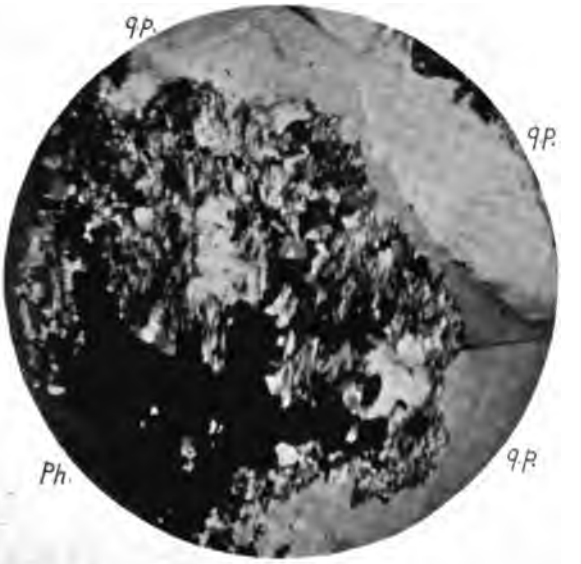


Figure 10



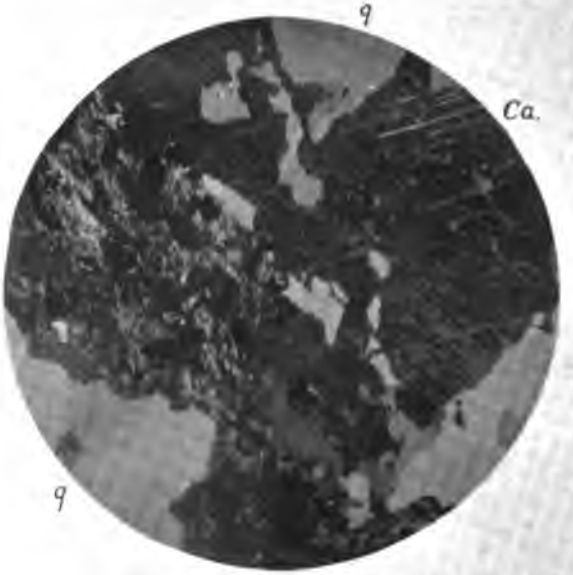


Figure 11

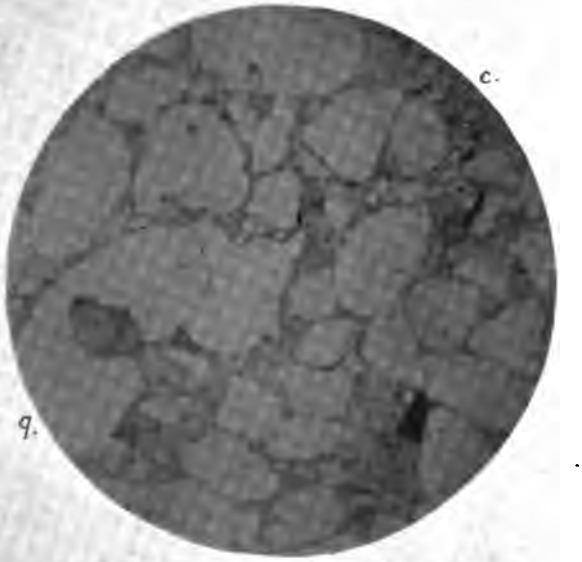


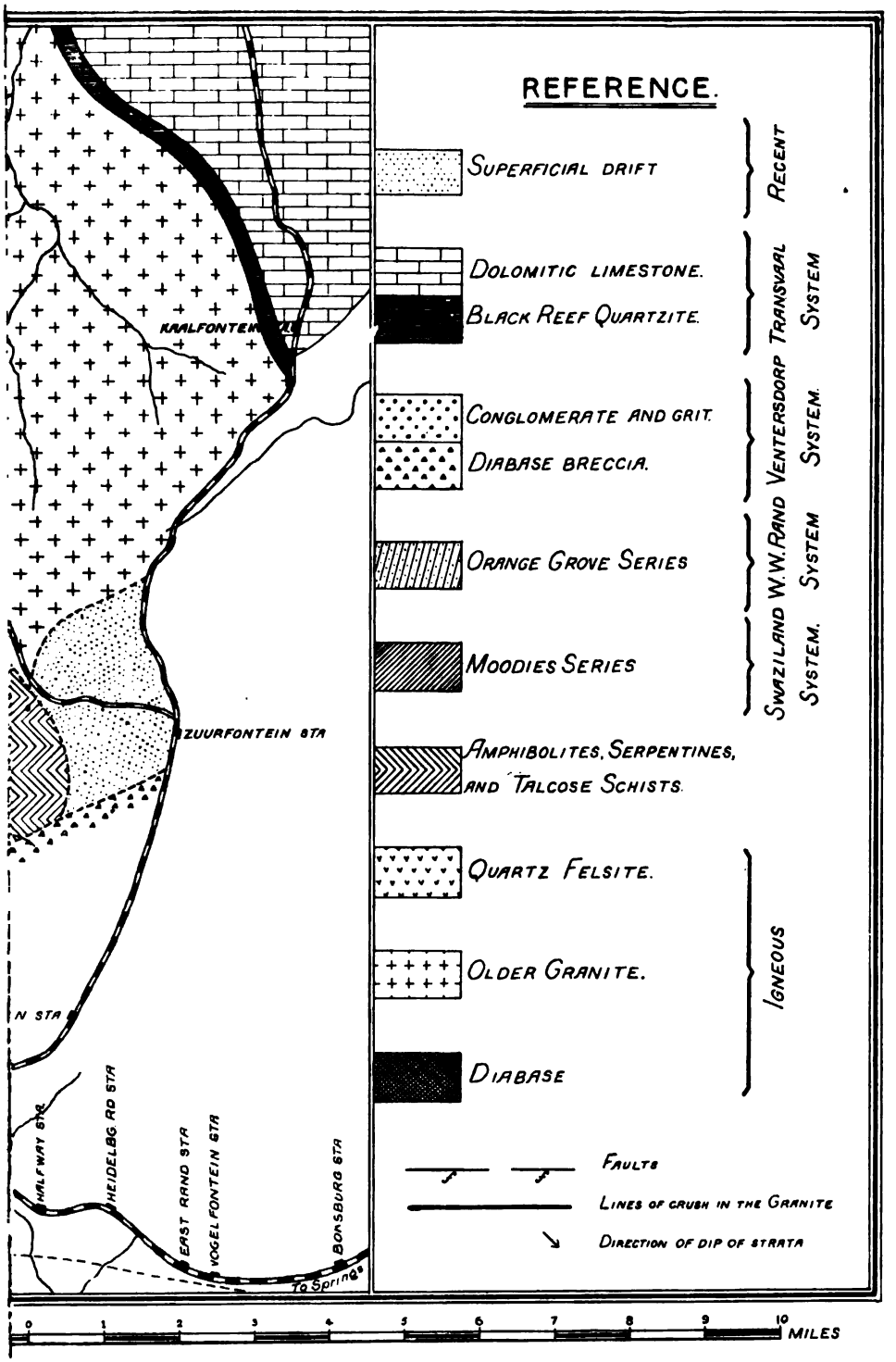
Figure 12

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google



Digitized by Google

Digitized by Google

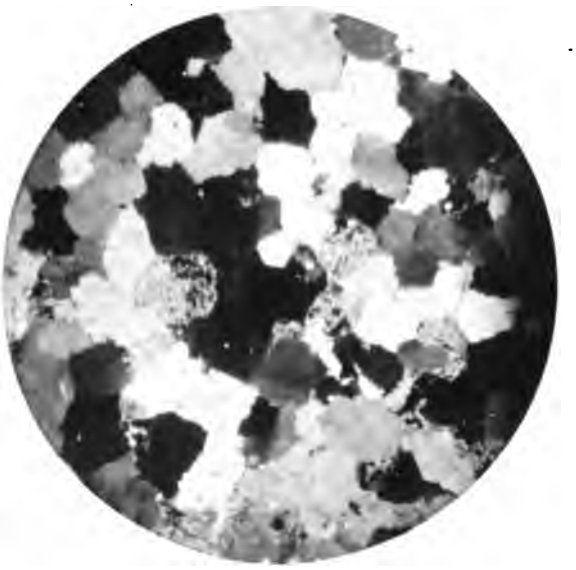


FIG. 1.

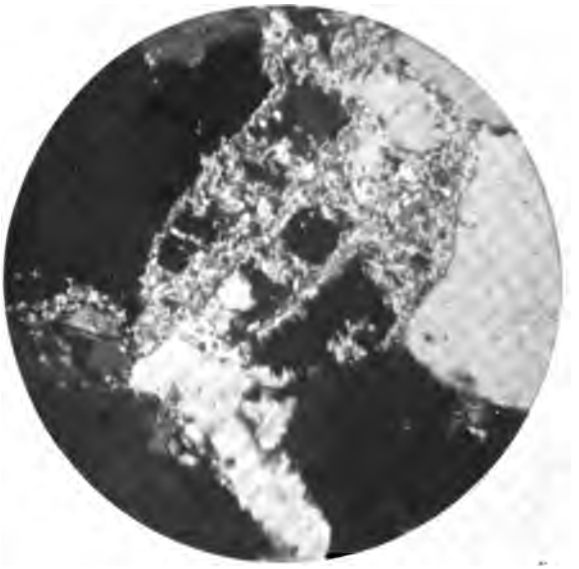
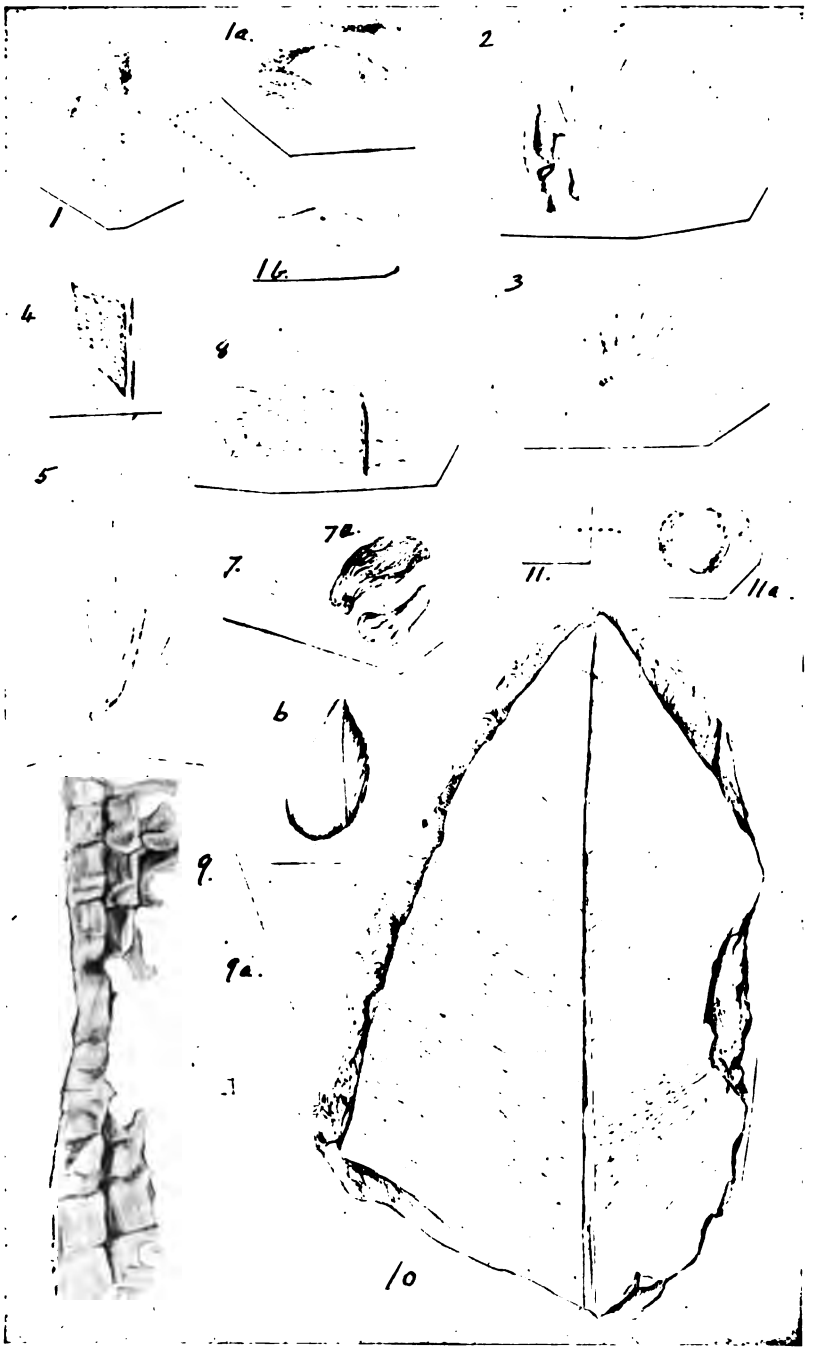


FIG. 2.

Digitized by Google

Digitized by Google

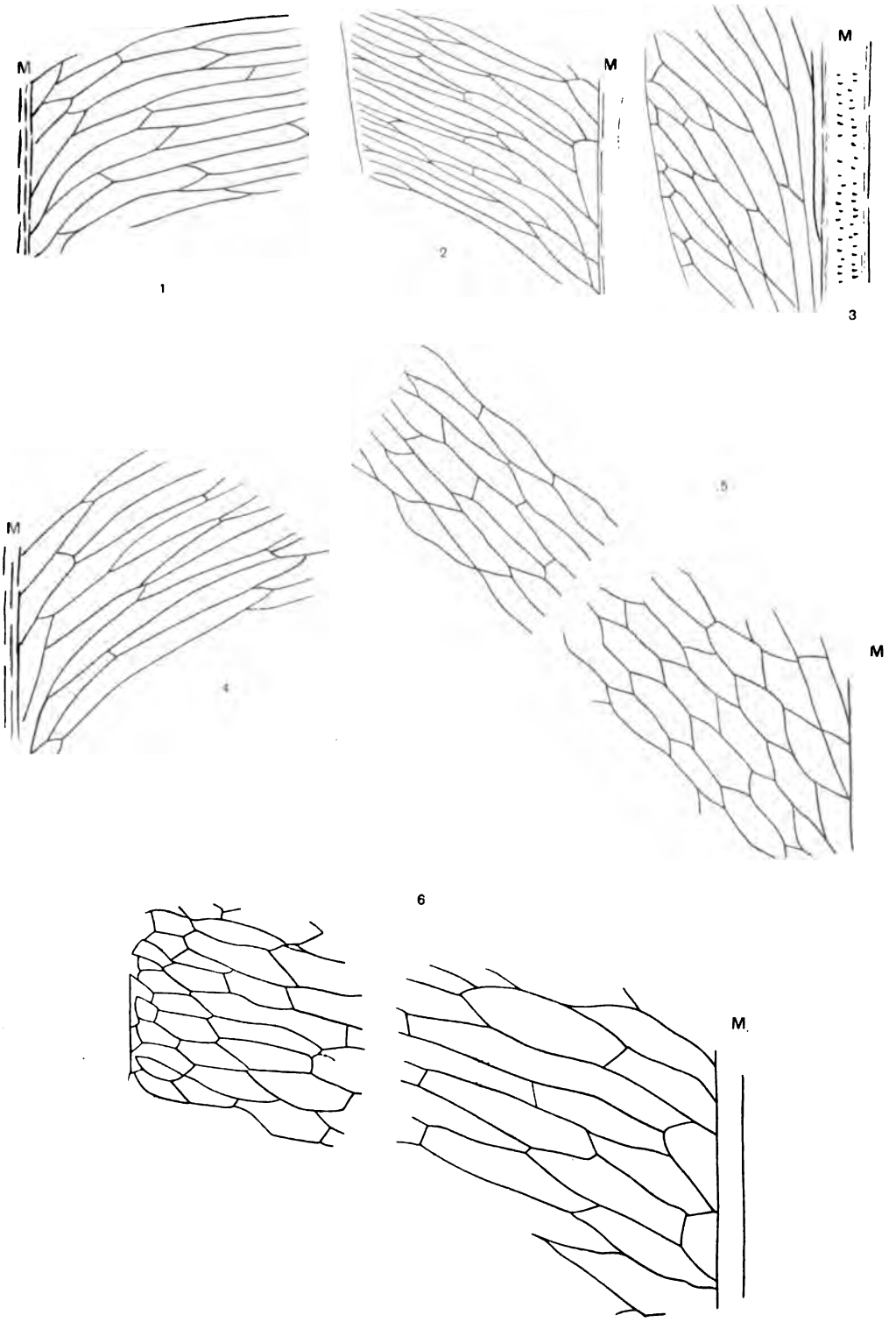


E. Wilson, del.

BOTHRODENDRON—PHYLOLTHECA—GLOSSOPTERIS.

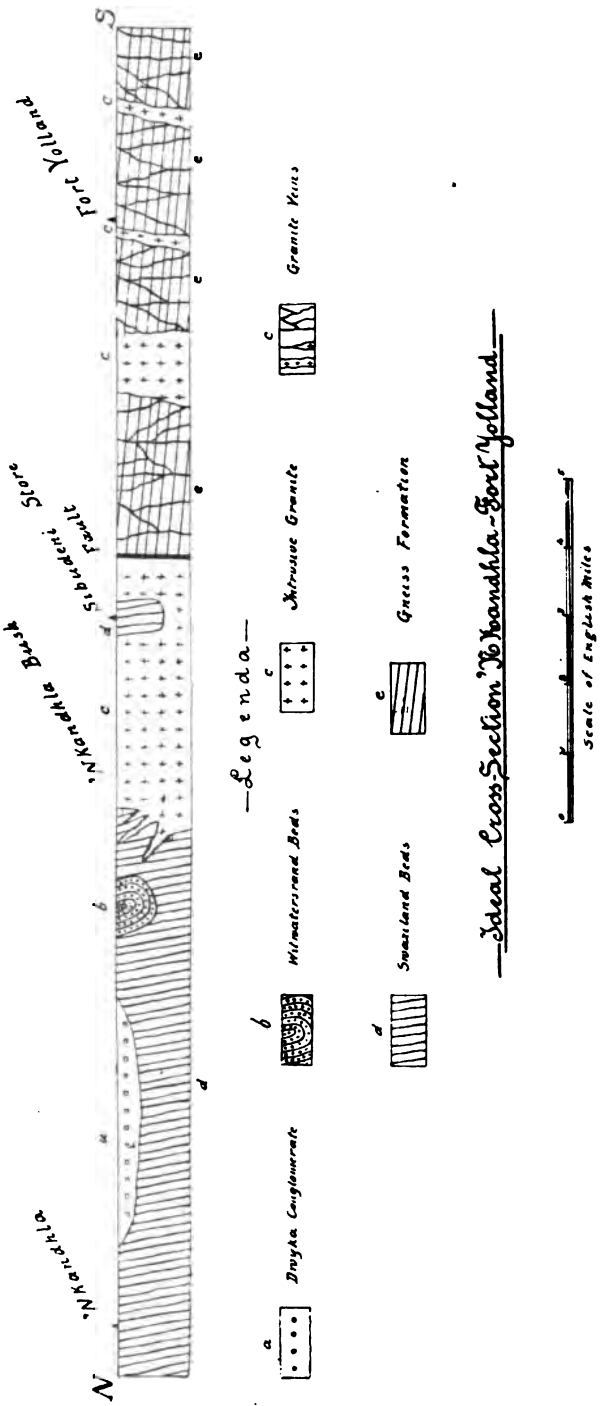
Digitized by Google

Digitized by Google



Digitized by Google

Digitized by Google



Ideal Cross-Section Nkandhla-Fort Yolland

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google